REPORT

OF

THE SECRETARY OF THE NAVY,

COMMUNICATING

A report of the plan and construction of the depot of charts and instruments, with a description of the instruments, &c.

FEBRUARY 18, 1845.

Read, and referred to the Committee on Naval Affairs.

FEBRUARY 20, 1845.

Ordered to be printed, and that 400 additional copies be furnished for the use of the Senate, and 200 copies for the use of the Navy Department.

NAVY DEPARTMENT, *February*, 17, 1845.

SIR: I have the honor to transmit a copy of the report, and the drawings accompanying the same, of Lieutenant J. M. Gilliss, on the erection of a building in Washington, as a depôt for charts and instruments.

I am, very respectfully, your obedient servant.

J. Y. MASON.

Hon. W. P. MANGUM,
President of the Senate.

WASHINGTON CITY, *February* 7, 1845.

SIR: I have the honor to transmit, herewith, a report detailing the plan and construction of the depôt of charts and instruments, with an outline of its astronomical instruments, library, &c.

In preparing this account, I have been influenced by a paragraph in a report from the council to the members of the Royal Astronomical Society, in which they state:

"The council are of opinion that it would tend materially to the advancement of astronomy, if an accurate description of every principal observatory could be obtained, accompanied with a ground plan and elevation of the building; together with a description of the instruments employed, and drawings of such as are remarkable, either for their novelty or peculiar interest. It is well known that there are several instruments in constant use on the continent, and much approved by astronomers, which have not yet been seen in this country; and some in this country, which are not sufficiently known abroad, or even amongst ourselves. The council would encourage every attempt to promote this species of information, by publishing in their memoirs the accounts which they may from time to time receive on this subject, and the drawings with which they might be accompanied. It is only by such a mutual interchange of information that nations can expect to benefit by their intercourse with each other."

Most respectfully submitted.

J. MELVILLE GILLISS.

Hon. J. Y. Mason,
Secretary of the Navy.

REPORT

ON

THE ERECTION OF A DEPOT OF CHARTS AND INSTRUMENTS.

A law authorizing the erection of a depôt of charts and instruments for the navy, was passed by Congress during the session of 1841–'42, the expense being limited to twenty-five thousand dollars. Taking the report of the naval committee, which accompanied the bill, (*see Report No.* 449, *House of Representatives, session* 1841–'42,) as the exponent of the will of Congress, the honorable Secretary of the Navy directed me, on the 9th September, 1842, to visit the principal Northern cities, for the purpose of obtaining information respecting a plan, which, whilst it combined essentials, should not exceed in cost the appropriated sum. Professors Bache, Bartlett, Bond, Hassler, Paine, Patterson, and Walker, were consulted, and on my return to Washington, the department assigned G. F. De la Roche, Esq., to draught plans, under my direction.

The only guide as to the probable amount a suitable building might cost was an estimate made by a highly respectable builder in Washington, upon a plan prepared by me for the naval committee. This plan was manifestly inconvenient, as it proposed a central edifice for office and residence, and two detached buildings for the observatories ; and a cruciform model seemed to be most generally preferred by the learned professors. In preparing conformable drawings and specifications, lest the limits of the law should be exceeded, the apartments absolutely necessary for the charts and instruments were kept of suitable dimensions, while those for the astronomical instruments were designed of the smallest possible size, and the magnetical observatory kept entirely distinct. Other objectionable and inconvenient arrangements were submitted to, from the same cause.

The plans prepared having received the sanction of the department, a contract for executing it was entered into with Mr. William Bird, in November of the same year. Under the instructions of the honorable Secretary, the drawings were subsequently taken to Europe, and presented to several of the most distinguished among the English and continental astronomers, for such suggestions as their greater experience might have found advisable ; and the model for the building finally adopted, embraces all the improvements upon the original plan recommended by them. New drawings, embodying the changes, were prepared in London, and I returned to the United States in March, 1843.—Plates 1, 2, and 3, represent ground plan, elevation, and sectional views of the depôt.

The law of Congress directing its erection, authorized the President of the United States to locate it on any public ground within the District of

Columbia, not otherwise appropriated; and the site assigned by him is known in the plat of the city of Washington as University Square. It lies on the north bank of the Potomac, in the southwestern part of the city, and contains about nineteen acres; the north front being 810, the east 1,103, and the west 620 feet long. By authority of the department, I had intended to place the building in such manner that the meridian transit would have a horizontal range along the centre of 24th street, but the astronomer royal at Greenwich, considering the advantages to be gained entirely unimportant, and that it would be better to consult architectural effect, the spot selected is at the intersection of the axes of D and 24th streets prolonged; the former running east and west, the latter north and south, and both terminating at the enclosure. This spot is 95 feet above ordinary high-water mark; has a north horizontal range one and a quarter mile, and a south range of eight miles. It is 267 feet from the north, 320 from the east, 490 from the west, and 900 from the south enclosure; the last bordering on the canal, beyond which is the river. The hill is of gravel formation, with a surface stratum of dry, brittle clay, through which water filters almost as freely as through gravel.

The ground was excavated to a depth of 8 feet, for the foundations of the walls and bases of all the piers, except that for the great telescope, which is 9 feet below the surface of the ground. The end wall of the west wing and foundation for meridian transit piers is several feet deeper than the others, owing to a natural fall in the ground rendering it necessary to excavate to a greater depth. Directions had been given, too, to go down to the gravel* for a base to the central pier, and the contractor had attained a depth of 17 feet before I returned to the United States. The position of the house being changed 25 feet to the west, the east wall and pier for the portable transit instrument fell within the cavity; they were therefore built up of solid masonry from the depth of 17 feet below the surface, instead of filling the hole with earth.

The central building is 50 feet 8 inches square on the outside, from the foundation to a height of 2 feet 6 inches above the ground; and thence to the top of the walls, 50 feet square. All the foundations to the ground line, are of blue rock, 2 feet thick; the remainder of the outside walls are of brick, 18 inches thick, finished in the best manner; and the partition walls are of brick, 14 inches thick. It is two stories and a basement high, with a parapet and ballustrade of wood around the top, and is surmounted by a revolving dome, 23 feet in diameter, resting on a circular wall, built up to a height of 7 feet above the roof. Its roof is nearly flat, having a rise of only one foot in ten; it is coppered, and covered with a grating, resting on supports secured to the parapet on one side and the roof on the other, so as to form a level promenade for gazing observations. There are four rooms on each floor, separated by passages 10 feet wide, crossing each other at right argles. Where the dome wall crosses the passages, it is supported on lintels formed by bolting together five thicknesses of timber, 12 inches wide by 4 inches thick, over which a brick arch is turned. There is, at the intersection of the passages, a foundation of masonry, laid in hydraulic cement, for the great pier. Its diameter at the base is 15 feet, and it is solid to a height of 10½ feet, where the diameter is 12 feet. Upon this is erected a conical pier of hard-burned brick, laid in the same man-

*Subsequently found at 27 feet from the surface.

ner; the diameter at the base being 12 feet, the height 28 feet; diameter at top 7 feet, and walls 3 feet thick, to within 10 feet of the top, where they gradually increase in thickness, and the last three feet is solid. The pier is capped by New York flagging stone, on which rests the pedestal of the equatorial.

Stairways from the basement to the second story are of the ordinary kind; but from the second story to the rotundo or dome it is spiral, commencing beside the vertical casing, (which prevents contact with the great pier;) it proceeds to a landing at the circumference of the dome, the aperture in the floor being closed by closely fitting doors, which are kept up by counterweights when the observer is not employed.

One room in the basement is occupied by the warm air furnace, one for fuel, and two for workshops of the instrument maker and lithographer. In the first story is the library and computing room, office for the director, office for the assistants, and chronometer room; and in the second story are rooms for draughting, instruments and charts. There is a discharging flue from the furnace in every room, and two in the passages of the second story.

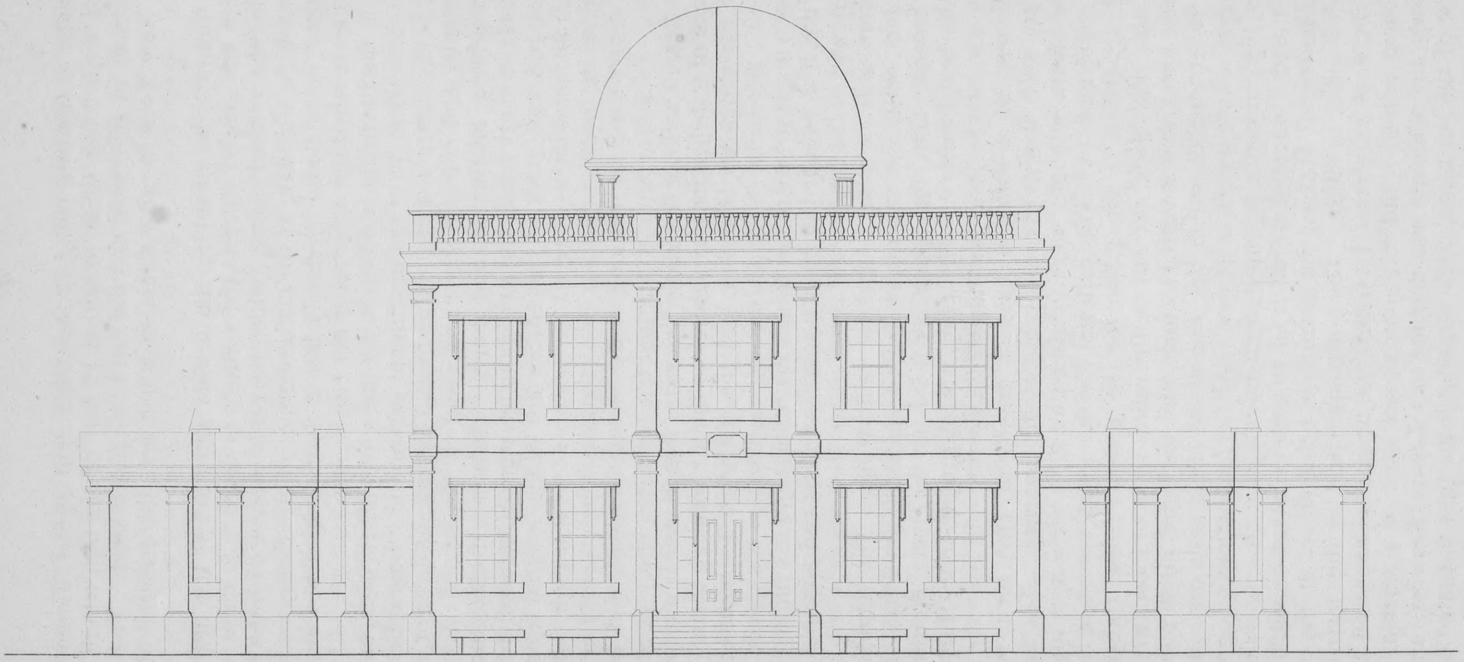
To the east and west sides of this edifice are wings, entered from the passages, each 26 feet 6 inches long, 21 feet wide, and 18 feet high. There is also a wing to the south, separated from the house by an entry or passage 10 feet square—it is 21 feet long, with the same breadth and height as the others. To guard against unequal temperatures, likely to be produced by the heated walls of the house,* an extra 9-inch wall is interposed, leaving a space of 6 inches for free passage to the air between them. The side walls of the wings are 18 inches, and the end walls 14 inches thick, the former being strengthened by pilasters on each side of the doors.

In the west wing is the meridian transit instrument and the mural circle; in the east wing, it is intended to place a meridian circle and portable transit instrument, and in the south wing is the transit instrument in the prime vertical. There will be also a clock to each wing. The foundations to all the piers, with the exceptions before specified, are 4 feet longer and 4 feet broader than the space occupied by the piers themselves, and are of the best masonry. The piers are of granite from Maryland. Where there are two for one instrument, they were split from the same *boulder*, and rest on a common base of granite or blue rock, whose dimensions are such that it covers the top of the masonry. The models by which they were wrought were furnished by their respective makers, and strictly conformed to. The pedestal for the great telescope is one block, weighing about $7\frac{1}{2}$ tons; that for the prime vertical transit instrument is also one block, cut out in the centre so as to form two piers united at their bases, and weighs $11\frac{1}{2}$ tons; and the mural circle pier has been made in sections, of which the axis of the circle rests immediately upon the largest, whose weight is $3\frac{1}{2}$ tons. All the foundations being ready for the piers, the contractor put up a small building on that intended for the great pier, and I mounted within it an 18-inch variation transit, kindly lent me by *Lieutenant* MAURY, the instrument being placed at the centre of the intended main building. The horizontal circle of this instrument reads to 15″ by three verniers. Its transit and azimuthal axes and line of collimation being adjusted, and the approximate error of a sidereal chronometer known, the telescope was directed to α *Leonis* (*Regulus,*) and the tangent screw of the horizontal circle turned, till the time indicated by the

* Suggested by Professor Encke.

PLATE 1.

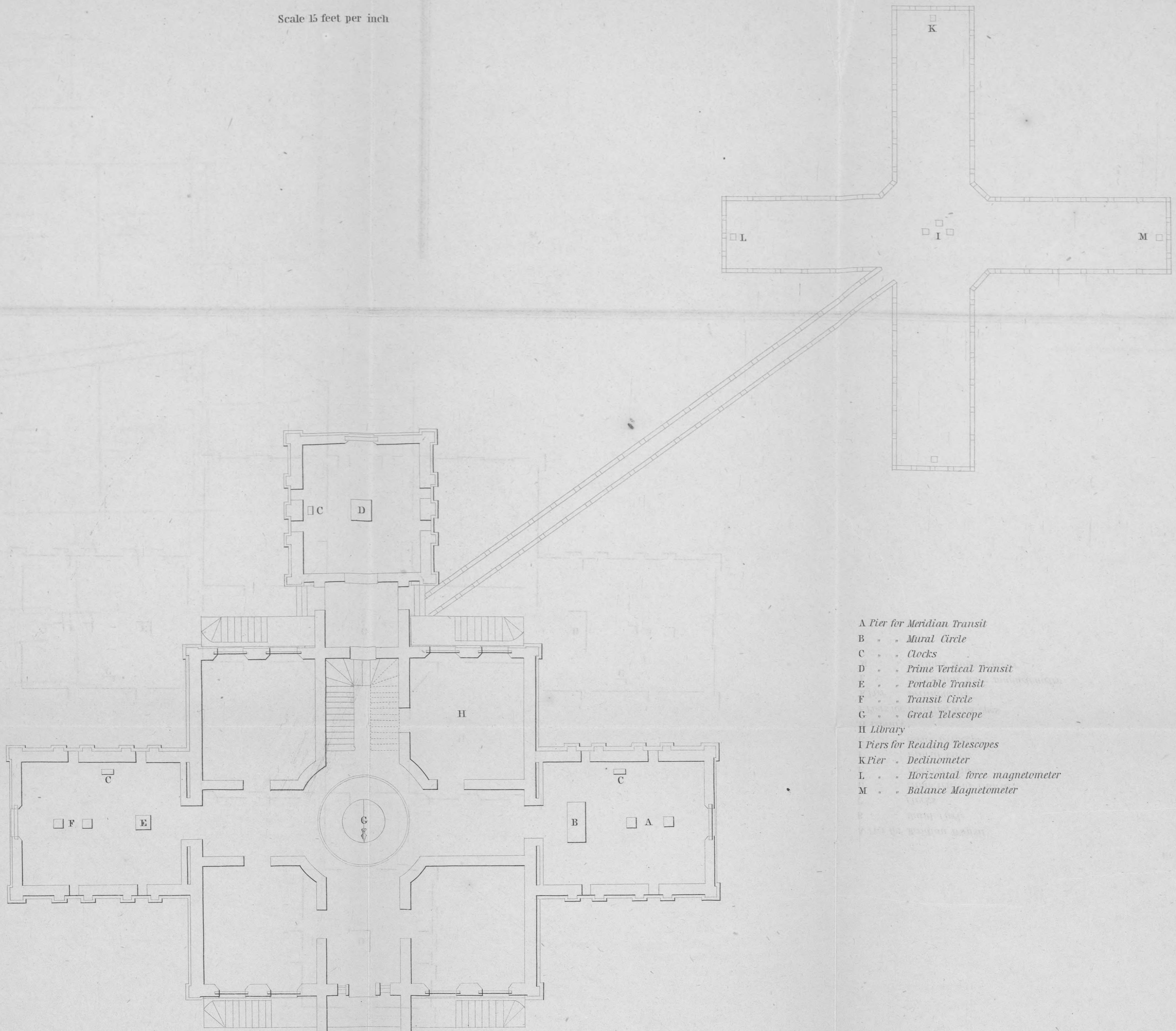
Scale 15 feet to the inch



North Elevation

PLATE II.

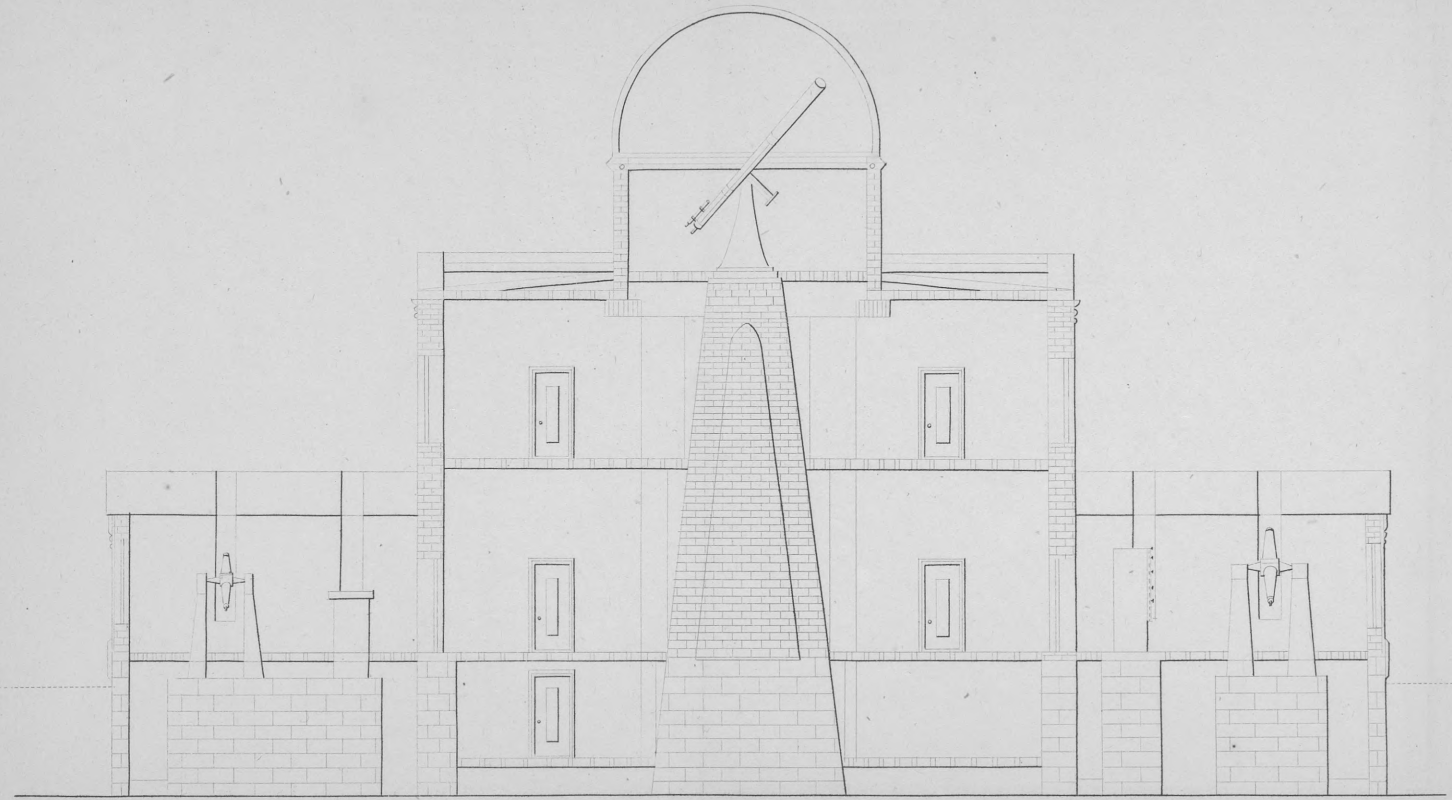
Scale 15 feet per inch



A *Pier for Meridian Transit*
B " " *Mural Circle*
C " " *Clocks*
D " " *Prime Vertical Transit*
E " " *Portable Transit*
F " " *Transit Circle*
G " " *Great Telescope*
H *Library*
I *Piers for Reading Telescopes*
K *Pier* " *Declinometer*
L " " *Horizontal force magnetometer*
M " " *Balance Magnetometer*

Drawn by Allexey Von Schmidt

PLATE III.

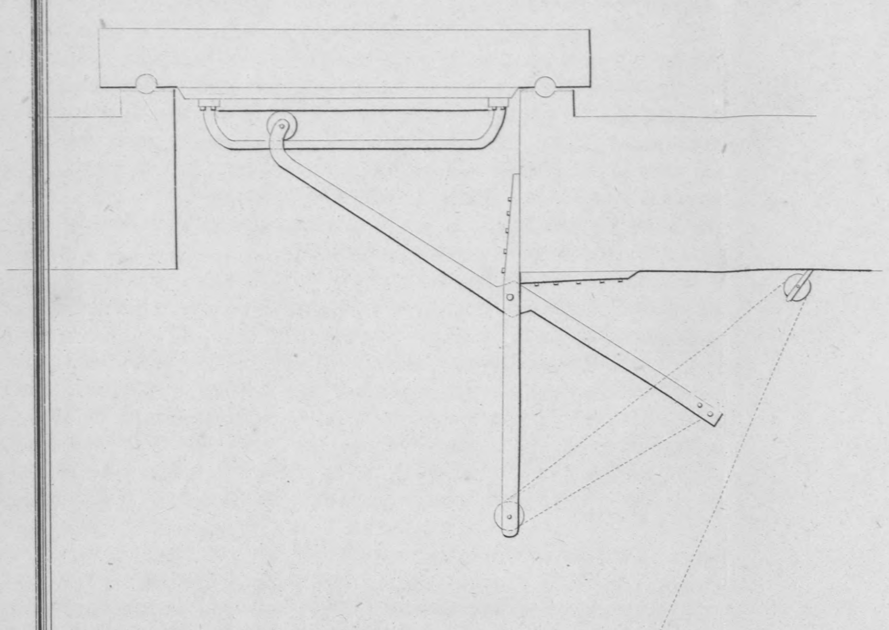


Section East and West

PLATE IV.

Scale one inch to the foot

Fig. 1.



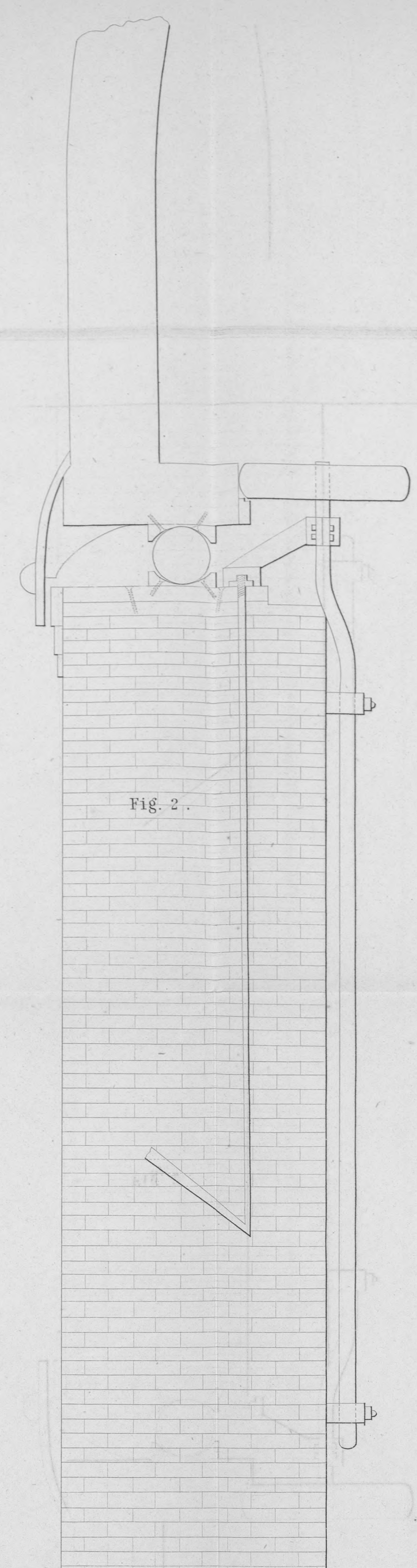


Fig. 2.

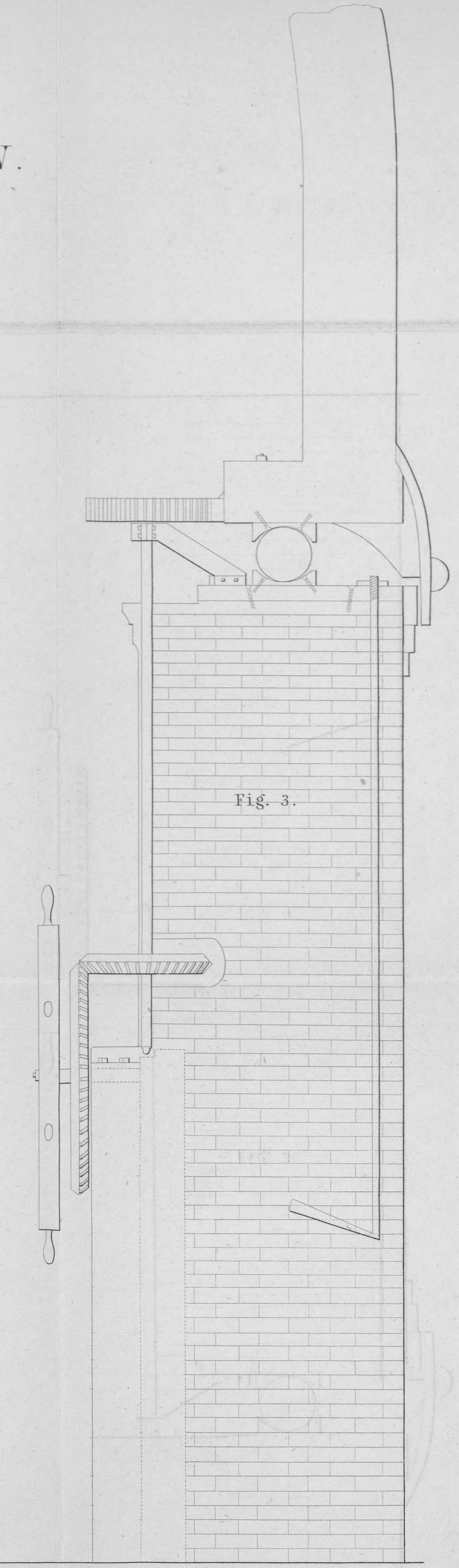


Fig. 3.

chronometer, ± its error, equalled the star's right ascension. The transit was then firmly clamped, its axis again levelled, and the following stars observed in this assumed meridian, viz:

α *Ursæ Major;*
δ *Leonis;*
δ *Hyd. & Crat.;*
γ *Cephei,* (S.P.;)
β *Leonis;*
γ *Ursæ Major;*
β *Corvi;*
12 *Canum. Venat.;*
α *Virginis;*
η *Ursæ Major;*

and the deviation therefrom computed by the formula $\Delta = D. \sin. \pi \sin. \pi' \text{co-sec.} (\pi \pm \pi') \sec. L.$*

Applying the mean of the deviations thus obtained to the reading of the verniers, the true meridian was found, and the tangent screw turned accordingly. On the following morning, strong stakes of timber were driven in the ground at the distance of 50 feet to the north and south, and a narrow slit was sawed in each, corresponding with the middle wire of the telescope. The same stars were observed on a second night except α *Virginis,* for which *Polaris* S.P. was substituted, a lantern placed behind the slits in the stakes affording a convenient illuminated meridian mark for reference before and after observation. A meridian being thus determined, the transit telescope was turned through 90°, and a second pair of stakes placed at distances of 100 feet to the east and west, with similar slits. Fine cords were stretched through the slits, and their directions marked on the base plates on which the piers were to rest, and in erecting which, the centre lines at their bases were made to coincide with those on the base plates, while those at their tops were viewed directly with the transit—thus insuring perpendicularity to the axis of the stone, at the same time that it placed it in the meridian. The piers being in place, were built up in masonry to a depth of 18 inches. For the pedestal of the great telescope, lines were cut in the foundation stone on opposite sides, corresponding with the meridian, and after completion of the brick pier, plumb lines attached to a long straight-edge were dropped from its summit, and the straight-edge moved, till the plumb lines bisected the marks thus cut. The difficulty of obtaining a day sufficiently calm, rendered this operation extremely uncertain, and it has since been ascertained that the axis of the pedestal is about 5′ to the west of the meridian, (when looking south.) All the others are quite accurate, and the piers are entirely insulated, there being no connexion with each other, or with walls, joists, or flooring of the house.

Lines for the walls of the building were determined by laying off others parallel to those ascertained for the piers.

To each wing there is a window in its gable end, fitted with a close inside shutter, (as are all the windows of the house,) and two openings on each side, in the meridian or prime vertical, 20 inches wide. The roofs have a rise of 3 feet, and are coppered; their pressure on the walls being relieved by iron rods, with screws and swivels at their centres, which prevent spread at the bottom of the rafters. Vertical doors to the apertures

* See explanation of III, page 27.

open inwardly, so as to be always under control, and are secured when closed by two ordinary iron door latches, connected by a light rod of iron. The roof or trap doors have common hinges, and open outwardly, being furnished with inside levers, cord, and pulleys, (PLATE IV, *fig.* 1,) contrived by Professor BARTLETT, and which do not require holes in the roof. They are frames of ash, covered with copper, lined on the inside with baize, and are fitted moderately close at their junction at the ridge, with a half-inch groove on their under sides, to prevent the entrance of water which may drive under the edges. Corresponding grooves in the door jambs effectually secure them at the sides, and a small trap over the junction, completes it at top. The door on either side of the zenith may be opened without reference to the other, as may also the vertical doors without regard to the roof doors; and the little trap, going up with the first, comes against a spring three inches from the perpendicular, and, in closing, is thrown down by the spring when relieved from the pressure of the last. So far, this arrangement has proved even snow tight.

The circular wall supporting the dome is laid with hydraulic cement, and has three windows and a door opening on the roof. The coping of the wall is formed by screwing together two pieces of 2-inch pine plank, cut into segments, 14 inches wide, and 7 or 8 feet long; the segments when put together *breaking joints.* That it may be levelled at any time hereafter, it rests upon wedges of wood; and it is secured to the wall by iron rods, (5 feet long, with screws and nuts at their upper extremities,) which are built therein, and, passing through its outer and inner edges alternately, screw it firmly down. To the centre of the coping, on top, is screwed a grooved cast-iron rail, the depth or versed sine of the curve being 1¼ inches, and in it, rest six equi-distant 32-pound balls. A dome curb is composed of three thicknesses of 2-inch pine, of the same width as the coping, and screwed together in the same manner, with a similar rail of cast iron on its under side, resting on the balls. The ribs are of two thicknesses of inch pine planks, 6 inches wide, placed at distances of 2 feet 3 inches on the curb, and united at top. An aperture 20 inches wide extends from the curb to 2 feet beyond the zenith on the opposite side. The dome is sheathed with half-inch boards, and covered with copper, the inside being lined with painted canvass. A cornice, projecting below the curb, protects the coping, and excludes rain or snow—such particles of the latter as might drive through the half-inch space between it and the wall being prevented entrance by a narrow canvass curtain within the cornice. The jambs to the 20 inch aperture or door are grooved in the same manner as in the wings, and, to close it, there are five doors, fitting quite closely together, No. 1, counting from top, lapping over No. 2 on account of its lying nearly horizontal; but, the others fit only so as to prevent binding. Hence any one can be opened without reference to the others, *except No.* 2; and to this I call especial attention, that the door may not be strained. They are stout frames of ash, grooved and covered as are the trap doors, the copper being turned up entirely across their bottoms, to form a gutter an inch wide, and throw off at the sides all the water falling on the door, instead of passing through the junction of the two doors. No. 2 is the only one which has leaked, and, as this arises from carelessness at its construction, may easily be remedied. Each door is furnished with a lever and pulley for opening it, similar to those of the trap doors, but proportionally lighter. The dome is kept in centre and prevented from wabbling by three equi-distant friction rollers on the inside, which turn on vertical shafts of wrought iron, 2 inches square by 6½ feet long, the rollers pressing against the curb of the dome, (PLATE IV, *fig.* 2.) These shafts are held in place by two collars of iron to each, built into the wall, and supported at top, or prevented from bending by iron frames secured to the coping with screw bolts. They may be adjusted to a vertical position, or tightened up, by wedges of iron fitting between them and the collars. The rollers are of cast iron, about 15 inches in diameter, with a broad band or tire, and their friction against the curb is increased or diminished by the wedges.

Immediately below the rollers, and secured to the curb by screw bolts and nuts, is a cast-iron rack wheel, in sections of about 2 feet each, any one of which may be removed without disturbing the others. On one side of the rotundo, and close to the wall, a wood column, (PLATE IV, *fig.* 3,) 6 inches by 4 inches, is bolted to the joists below the floor, and its top is about 3 feet above it. This receives a cast-iron cap, in which there is a horizontal aperture for the axis of a hand wheel and a step on top for the lower end of a vertical shaft. The hand wheel turns vertically, is about 3 feet in diameter, is fitted with spokes, and carries on its axis a bevelled pinion. The vertical shaft is held in place at top by a collar bolted to the coping, and has two pinions—a lower bevelled one 14 inches in diameter, working into that of the hand wheel, and an upper one of the same diameter working into the rack wheel. The space occupied in the room is less than a foot from the face of the wall, and a power of 10 pounds applied to the hand wheel is quite sufficient to turn the dome; once the inertia is overcome, 5 pounds will keep it in motion. To prevent its blowing off, an extra half inch was cast on the iron rack wheel, between which and the friction rollers there is left just space to avoid contact ordinarily, but that will immediately resist the lifting of the dome; and, to get off, it must rise through the versed sine of the annular rail, viz: 1¼ inch. The weight of the dome is estimated as follows, a cubic foot of pine being valued at 35½ pounds:

	Pounds.
Curb and bolts or screws - - - - - - -	1,500
Iron railway and screws - - - - - - -	900
Rack wheel and bolts - - - - - - -	500
Ribs and nails - - - - - - - -	1,300
Sheathing of wood and nails - - - - -	1,600
Copper and nails - - - - - - - -	1,200
Lining, paint, and nails - - - - - -	200
Levers, cornice, &c. - - - - - - - -	500
Making an aggregate of - - - - - - - -	7,700

or rather more than three tons, which is probably less than the absolute weight by 500 pounds.

THE MAGNETICAL OBSERVATORY.

It was originally intended that the DUBLIN magnetical observatory should be taken as a model for the one to be erected in Washington, except that, instead of stone, the latter should be built of wood, with a double frame, and the spaces between the frames filled with some non-conductor of heat; but, upon the award of the contract, there being a balance of appropriation to justify it, it was determined to place it under ground, as was recommended by scientific gentlemen, as well at home as abroad. An excavation in the form of a cross (PLATE II) was therefore made to the southwest of the central edifice, with a gallery leading into it from the south basement door. The length of this gallery to the centre of the cross is about 95 feet, its width 4 feet 6 inches, and height 7 feet, with a gradual declination from the entrance to the observatory floor. The excavation was cut 72 feet long in each direction, (east and west and north and south,) 12 feet wide, 16 feet deep, and was completed in June. The depth was considered sufficient to secure uniformity, as the floor would be below mean temperature, and it was supposed that if placed at 5 feet under the soil, the roof would be beyond leakage arising from filtration of rain. That of the observatory at Munich is level with the soil, and it is subject to nearly all the changes of temperature.

The angular points at the intersection of the arms were cut off, so as to give the centre an octagonal form; and there being but little rain during the early part of the summer, the walls of earth were well dried when the carpenters began putting up the frame, about the middle of August. This is composed of yellow pine timber 10 inches square, with studs, roof, and floor joists 10 inches wide by 4 inches thick, secured by wood pins or copper bolts. An outside planking $2\frac{1}{2}$ inches thick, and also of yellow pine, is kept in place by dry powdered earth rammed hard round it; the inside planks or linings are of 1-inch white pine, fastened with copper nails, and the floor is of yellow pine, secured with wood pins; nor has any iron or steel been used in the construction of any part of the building. Its interior dimensions are—70 feet long in each direction, 10 feet wide, and 10 feet high; those of the gallery have been given already. An octagonal dome light over the centre of the cross, fitted with double windows, affords light for observation during the day; and there are two small doors under the dome, besides the entrance door, through which air may be admitted, when wanted inside. A small copper gutter, with spouts leading to the outside, serves to collect and convey away from the glass all the condensed moisture of the dome.

Four marble pillars have been placed in the extremities of the cross, for the support of the instruments, and three others near the centre, for the reading telescopes and scale—the observer occupying a seat in their midst. The pillars are eighteen inches in the ground, and three feet six inches above the floor, from which they are insulated. All the reading telescopes may be reached from one seat, and one observer is enabled to record the position of all the instruments, even on term days.

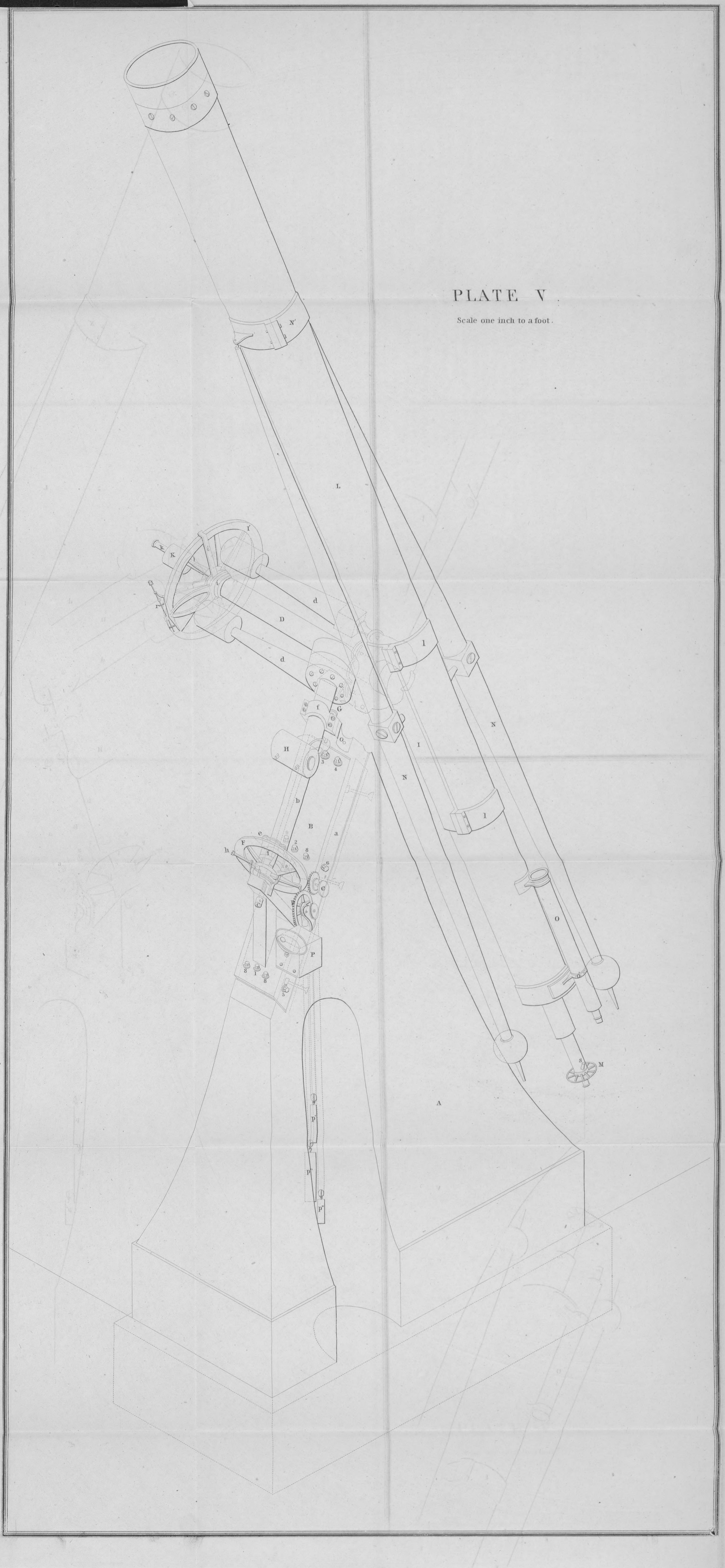
The earth over the roof was raised to a height of five feet, sloped to throw off the water, and sodded over—and the building entirely enclosed about the middle of September, 1843. Between that time and the month of December following, the range of temperature was only $3\frac{1}{2}°$ Fahrenheit; nor was the thermometer lower than 48° during the succeeding winter, although it fell to 0° in the open air.

THE INSTRUMENTS.

It being evident, from the report of the committee of Congress before named, that it was intended to establish a NAVAL OBSERVATORY in connexion with the depot of charts and instruments, it became an object of great importance to obtain instruments of such character in the various

PLATE V.

Scale one inch to a foot.



departments of *astronomy*, *terrestrial magnetism*, and *meteorology*, (designated by them to be pursued,) as would render the most efficient service during the largest portion of time. To this end, eminent advice was sought, and a list prepared for the approval of the honorable Secretary, which, regarding their ultimate usefulness as paramount, still kept economy in view. The list embraced—

1st. Achromatic refractor.
2d. Meridian transit.
3d. Prime vertical transit.
4th. Mural circle.
5th. Comet searcher.
6th. Magnetic instruments.
7th. Meteorological instruments.
8th. Books.

In addition to these, to be purchased, there belonged to the navy a portable 42-inches transit instrument and two clocks, purchased by Lieutenant Wilkes for the exploring expedition, and a 30-inches transit circle and two clocks, ordered for the depôt by myself; all which, with a number of mathematical, astronomical, and other scientific books, could be rendered useful in the new establishment.

ACHROMATIC REFRACTOR.

The year 1824 may be regarded as an important epoch in the history of astronomical instruments, *Frauenhofer* having mastered the optical difficulties and exhibited to the world his unrivalled Dorpat telescope. Born in poverty, and early left a friendless orphan; imbued with an unquenchable thirst for knowledge, but apprenticed to a glass grinder, who, regarding each moment not employed in labor as stolen from himself, sought to crush his desire for study by prohibiting books and even a light in his windowless chamber; it was not until the public excitement, caused by an almost miraculous rescue from the fallen ruins of his dark domicil, that his simple story reached the ears and touched the feelings of his sovereign, and a career was opened to him, better suited to his brilliant capacities. With mind to perceive and reason, mechanical knowledge to execute as well as order, and means to encounter disappointments, he perfected the discoveries made by Guinand,* in the manufacture of large discs of homo-

* I learned at Munich that the original firm, Reichenbach, Utschneider, & Liebhen, had their establishment at Benedictbourne, near Munich. Guinand was brought from Neuchatel after Utschneider had obtained the papers detailing his mode of making the glass, in 1805. Frauenhofer did not become connected with it till 1806-'7, nor a partner, till the withdrawal of Reichenbach, in 1820. Guinand made no improvements in his discovery, and shortly became too irregular in habits to be useful; but was pensioned for life by the firm. Utschneider survived Frauenhofer, and sold the reversion of the optical institute to Messrs. Merz & Mahler, its present proprietors; but just before death, and without cancelling the sale, was induced to make a will bequeathing all to the Government, which took possession at his decease. Merz & Mahler brought suit and recovered, compromising to deposite all the papers relating to the subject among the public archives, that the secret cannot be lost.

The furnaces are in the Tyrol, and surrounded with high walls; and so jealously is the art guarded, that Mr. Merz does not permit even his workmen to be present at the casting, but turns them all outside the walls. His son is probably the only person living capable to manufacture the glass, Mahler being the mechanician. There were completed and fitted into their cells one lens of 14, two of 12, two of 10½, and one of 9 French inches, which last I selected. Mr. Merz offered to construct one of *eighteen inches*, if I would allow five years for the completion of the telescope.

gereous glass, and the great Dorpat refractor was the first monument of his scientific skill. Striding over minor obstacles, he boldly aimed at achievements in optics, which the most earnest longings of astronomers had scarcely permitted them to hope for; and this instrument of nine inches aperture was scarcely completed, before an offer was made to construct one of *eighteen inches.*

In the prime of life, and "in the very heart of his gigantic conceptions, with inventions incompleted, ideas undeveloped, and speculations immatured," this pillar was torn from the temple of science; and there was not a practical astronomer, within the widest boundaries of Europe, who did not feel the tide of grief for the loss of Frauenhofer flowing within his own circle.* He slumbers by the side of Reichenbach; and on the tablet erected to his memory, his mourning countrymen have inscribed a volume in the words "*Approximavit sidera.*"

The reputation acquired by Frauenhofer for the institute has been preserved inviolate by his successors, though they seem not to have made any great improvements in either the optical or mechanical construction of his instruments; but, on the other hand, appearing to consider the standard left by him as near perfection as is desirable, they evince an indisposition to depart from it. Meanwhile, other opticians have grown up on the continent; and Cauchoix and Lerebours have turned out lenses, of 12 inches diameter, that have given their makers high character. Indeed, the $6\frac{6}{10}$-inches telescope, made by Cauchoix for the reverend fathers at Rome, will probably compare with Frauenhofer's best; and a trial of a 14-inch, recently completed by Lerebours, the Parisian astronomers seem to think, promises greatly to extend our knowledge of the moon's physical condition. Twenty years have elapsed since Frauenhofer's offer, and 14 French inches is the maximum diameter of any lens yet perfected. It is true that at the *exposition des produits de l'industrie nationale*, at Paris, this year, Lerebours remarks, upon his collection of optical instruments, "M. M. les membres du jury comprendront sans donte toutes les difficultés que j'ai dû éprouver pour réunir une collection† aussi complète d'objectifs de diverses dimensions que je regarde comme achevés. J'espère aussi qui ils me sauront gré de n'avoir pas cherché à attirer l'attention du public, en exposant un objectif de 18 *pouces* que je compte achromatizer dialytiquement, *et qui est actuellementen travail dans mes ateliers*;" and we may shortly hear of its completion. But the probable success of one seems to have roused the genius of rivalry; and a letter to M. Arago, from the proprietor of a glass manufactory near Paris, which was published in the *Comptes Rendus* last August, (I think,) encourages the belief that we may soon behold objects not less curious, perhaps, than the fabled visions of Sir John Herschell in the moon—the artist stipulating to furnish and grind discs, of suitable glass, a mètre ($39\frac{1}{4}$ inches English) in diameter! That he can make good his offer may safely be questioned, if the experience of tried opticians is to be credited. M. Lerebours says: "One must execute large object glasses, to obtain an idea of the numberless difficulties their fabrication presents. When Frauenhofer estimated that obstacles increased as the cubes of the diameters of the lenses, he was doubtless correct so far as

* See Silliman's Journal, vol. XVI.

† This collection embraced 1 lens of 4 inches diameter; 1 of 5, (achromatized dialytically,) and $3\frac{1}{2}$ feet focal length; 1 of 6; 1 of $7\frac{3}{4}$; 1 of 9, and focal length 10 feet; 2 of 12; and 1 of 14, with a focal length of 26 feet.

regards those from 4 to 9 inches in diameter; but beyond that size, the practical difficulties of execution augment in a truly alarming ratio. Thus, whilst 6 object glasses, of 6 inches each, present a surface nearly equivalent to one of 14 inches, I would greatly prefer making twelve of the first to one of the latter diameter."

Though the French artists have not occupied the same rank as those of Bavaria, the lenses of both are likely to deteriorate. Whether it arises from the greater attention they have received in polishing that the productions of the latter wear best, or whether it is owing to a difference in the proportions of the constituents, the constituents themselves, the temperature to which they are subjected, or the manner of cooling, no one but the artists can tell, and they are not likely to enlighten us. The experience of unbiased professional men of different nations becomes, therefore, the soundest basis on which to rest judgment. On one hand, Mr. Cooper's 12-inch French object glass, it is said, already exhibits traces of oxidation; on the other, I was witness to an arborescent appearance on the flint lens of a Frauenhofer, which, its proprietor said, had formed and continued to increase *since it accidentally got wet*, and to which there is little doubt that it is due. With the former of these two specimens, defect is apparently inherent—in the latter, fortuitous; and might, therefore, have been guarded against.

In England it is very unusual to obtain discs of flint glass above 4 inches in diameter, the excise laws amounting to an utter prohibition of experimental investigation absolutely indispensable to obtain a knowledge of its manufacture for optical purposes. Her distinguished instrument makers are therefore compelled to obtain from continental artists all the large object glasses for which they may receive orders for mountings—as do also the Repsolds at Hamburg, and Pistor & Martins at Berlin. If the productions were equally good, they would consult pecuniary interest, and purchase at the lowest prices; but this is not the case; for, whilst the French opticians have reduced their charges quite one-half, and the Bavarians have increased theirs nearly one-third, the preference is unquestionably given to the latter.

Unprejudiced makers, agreeing reasonably well respecting the optical portion of Frauenhofer's telescopes, are by no means of one mind as to the style of mounting; nor do English and German astronomers accord. The Germans I conversed with, among whom may be mentioned M. M. Schumacher, Encke, and Lamont, are unanimous; the English divided; those who object to it contending: 1st. Support at the extremity of the polar axis renders the instrument unsteady and tremulous in its motion. 2d. It compels a small hour circle. 3d. It requires reversal in passing the meridian. To the first of these, Struve says of the Dorpat telescope: "But the most perfect motion around the polar axis is produced by means of clockwork, which is the principal feature of this instrument, and the greatest triumph of the artist—the mechanism being as simple as it is ingenious. A weight, attached to a projection connected with the endless screw, overcomes the friction of the machine. The clock, vibrating in a circular arc, regulates the motion, by moving an endless screw connected with a second wheel in the above projection. The weight of the clock, as well as that of the friction, may be wound up without the motion being interrupted. When the telescope is thus kept in motion, the star will remain quietly in the centre, even when magnified seven hundred times. *At the same time, there is not the* *least shake or wavering of the tube, and it seems as if we were observing an immovable sky.*" And, after using it from 1825 to the foundation of the Pulkova observatory, in 1838, a period of 13 years, ordered for that imperial establishment another instrument of the same construction, but nearly double the dimensions, where the instability must, of course, be increased in an extraordinary ratio. Nor do Professor Encke or Dr. Lamont, who are furnished with similar instruments, find any fault. The other two objections are, perhaps, comparatively unimportant, observations being generally of a differential character, and an hour circle of 15 inches readily permitting a reading of absolute right ascensions to half a second of time; and the range on each side of the pedestal being more than an hour beyond the meridian. But is the English style a certain guaranty against the alleged defects of Frauenhofer's? Only two large telescopes have been thus manufactured. One, presented to the observatory at Cambridge by the Duke of Northumberland, which was erected from plans and under the diriection of Mr. Airy; the other, mounted by Troughton & Simms, for Sir James South, at Kensington; Mr. Cooper's being by Grubb, of Dublin, after a slight modification of Frauenhofer's plan. Of the first, no detailed account has been published, nor have I heard any rumors of instability; but the mounting of Sir James South's *was broken to pieces* two years ago, its proprietor considering it useless, from this very cause. It would appear, too, that if the tremulousness be got rid of, it is at the expense of making the instrument cumbrous, or the certain risk of flexure, besides the loss of a portion of the northern firmament; objections whose probabilities increase as the position of the observatory is nearer the equator, and to which Frauenhofer's telescopes are not liable.

It was therefore determined to confide the construction of the equatorial to Messrs. Merz & Mahler, the only changes I proposed being the substitution of a stone pedestal for the stand of wood, and prismatic for direct oculars to the hour circle. The instrument was packed in fourteen strong embaled cases, and shipped from Bremen for Baltimore about the middle of March, 1844, reaching its final destination safely on the 28th May last.

A strong scaffolding was erected round it, and the pier (A, PLATE V) prepared for mounting the telescope, by cutting cavities at right angles to its inclined face, for the nuts and screws of the base or bed, plate *a*, which is of brass. The inclination of the face to the horizon is 39°, and the bedplate nuts and screws being in the places they were intended to occupy permanently, a cement was made by melting repeatedly together, at a temperature rather below the ignition of sulphur, nine parts (by weight) of sulphur, five of stone dust, (granite,) and one of beeswax, and poured into the cavities warm, care having been taken to wrap the screws in oiled paper previously. Of these last, there are six, more than half an inch in diameter, and with their heads let in flush with the top of the bed plate. As soon as the cement was properly cool, the paper was removed, screws well greased, and the plate firmly fastened down.*

Upon this fits a heavy brass frame B for the support of the polar axis; and, indeed, the whole instrument, it being secured to the bed-plate on top by four steel screws 1, 2, 3, and 4, with hexagonal heads, and nearly

* Sulphuric acid evolved from this cement blackens the silver, but it is believed that it may be arrested by a coating of suitable varnish. It was preferred, from its greater tenacity, the plaster of the transit instrument on Capitol hill having given way on the absorption of moisture condensed by the piers at a sudden change from cold to warm damp weather in winter.

an inch in diameter; and at the sides by four similar ones, two of which, 5 and 6, are seen. There are, besides, four adjusting screws 8, 8, 8, 8, on top, by which its lower end may be elevated, two at the bottom and two midway; and the four side screws, while preventing it from rising, serve also to move it in azimuth, the range being rather more than half an inch each way, when the two central lines coincide. The endless screw C, which works into a corresponding thread of the hour circle, was next put in place, the convex face of a small rectangular metal plate on the west side being turned outward, and its larger portion against the reaction spring.

The declination box D, of brass, (without the balance rods *d d*,) and the conical polar axis (of steel) *b*, were fastened together by eight steel screws. the latter being vertical at the time. After wrapping the axis in soft paper, a triangular piece of steel *e*, with two friction rollers and a spring, intended to relieve the strain upon the lower collar, was put on, and then the hour circle F, which is fifteen inches in diameter, and reads by two verniers to 2", and its brass holders *h h*, for the prismatic reading glasses to the verniers. The whole was lifted carefully into place upon the frame, a piece of oiled parchment introduced between the lower end of the axis and a square plate of brass attached to the lower projection of the frame by sliding pins, the collars *f f* put on and screwed down, the paper removed from the axis, and friction rollers of the triangular piece placed in a groove turned for them in the lower part of the axis, the spring tightened by the screw underneath, and the declination box propped up with a board to a position nearly horizontal. The square plate of brass has a motion in the direction of the axis by a fine steel screw *c*, that the friction of the axis which presses against it may be reduced in the two collars.

Two friction rollers G, set into a triangular frame, are secured by a strong steel screw under the upper part of the polar axis, having (with the frame also) a slight vertical motion; and a forked lever holding the counterpoise, H, with its fulcrum at *o*, in the upper projection, forms the immedate support of the instrument, and relieves the pressure in a great measure from the lower part of the top collar.

The declination axis, passing through the box D, is conical and of steel, its extremities being turned accurately, and ground into the box. It is strongly screwed to the brass cradle I, and has around a flange near the cradle a metallic ring, holding friction rollers that travel in a groove of the flange. There are two holes in the ring to receive the ends of the small balance rods *d d*, which were next secured in place without the weights; and a small brass hook, screwed to the declination box, passes between pins on the ring or roller piece, and keeps it from turning. The balance rods move about double axes, that they may accommodate themselves to every position of the instrument. On lifting the declination axis and cradle into place, these rods were guided to their proper holes in the ring and the hook between the pins, after which the weights were screwed on to the rods. A brass *check-piece*, *i*, (so called by the makers,) with four arms, intended to hold the verniers; and a fifth, *i'*, with adjusting screws for the index error or position of the verniers, is firmly driven on to the declination box, and secured by screws, which pass through it and into the box. The clamp circle is next put on, a steel washer between it and the check-piece, with its convex face outwards, acting as a spring; then the declination circle I' and holders for the reading glasses; and the whole is secured with a large brass nut. The declination circle is 21 inches in diameter, and reads by four verniers to 4″; but may easily be subdivided by estimation. A short piece of steel, *k*, of cylindrical form, screws into the outer extremity of the declination axis, and has a movable counterpoise K retained at any desired point by the friction of a screw passing through it. This being placed on, and its end-nut screwed up, the board was taken from under the declination box, and the portions of the instrument fitted together allowed to rest at their gravitating point. The utmost caution is necessary, until the large brass nut confines the circles and declination axis within the box, that the cradle does not tilt and fall out.

The tube L is composed of light strips of deal or white pine, glued round an inner frame of paper, on hollow metallic discs, and veneered on the outside with mahogany. Each end is capped with brass, the object-end being fitted for the reception of a frame containing the object glass, and the eye-end a tube, with a second smaller one sliding within in it, to which is screwed the eye-pieces, or repeating filar-micrometer M, and moved to distinct vision by a tangent screw. Its length is 15 feet 3 inches. An aperture beneath receives a projection of the declination axis through the cradle, and brass bands *l l* hold it firm.

Spherical counterpoises screwed on to the hollow brass rods N N overcome the preponderance of the object end, and prevent flexure of the tube by its support at the brass band N′; and that these great balance rods may accommodate themselves to every position of the telescope, they turn about double axes, as do the smaller ones. There are also cylindrical weights, which may be screwed into those of spherical form, when the filar-micrometer is removed, and thus restore the equipoise.

The finder O has an object glass $2\frac{6}{10}$ inches clear aperture, a focal length 32 inches, and has a tube of brass. That it may be attached to the telescope, the frame holding its object glass must be taken off, when the tube may be passed through the supporting ring O′, containing four adjusting screws, by which the two optical axes may be made to coincide. The object glass of the telescope is $9\frac{6}{10}$ inches in diameter, with a focal length 15 feet 3 inches, and the time occupied in perfecting it was nearly two years—six screws secure it to the cap.

A clock P, with centrifugal pendulum revolving in an inverted conical box on top, communicates motion by an endless screw to the wheel *p*, which again transfers it to the pinion of the endless screw working in the thread of the hour circle; and as this is permanently fitted on the polar axis, the telescope turns with it. The clock is kept in motion by the weight *p*′; the friction of the instrument is overcome by *p*″, whilst *p*‴ prevents *p*″ running down, and the time is regulated by an excentric key on the face, which raises or depresses the pendulums in the conical box, and thereby diminishes or increases their friction. As this may be accomplished instantly by means of the excentric, furnished with a pointer and graduated dial, the observer may bring a star to the centre or any other point of the field "by rendering the motion of the instrument, for a time, faster or slower than that of the heavens; and when once placed, it may be kept in that position by returning the hand to its original situation." The endless screw terminates in a conical shaped head, over which the small pinion fits as a cap, and the two are brought into contact at their conical surfaces, by a spring and catch operated by cords leading through pulleys to the hand of the observer; one throwing it into, the other, out of gear, and the friction of the cap and head being sufficient, when the former is turned by the clock, to set the instrument in motion. When it is desired to move it through a large arc at once, a small lever working by the rectangular plate on the west side, serves to throw the endless screw out of or into the thread of the hour circle, and a Hook's joint handle fitted to the end of this screw, enables the observer to control the motion, when in its approximate position. But no attempt must be made so to use it while the clock is in connexion, as it will be attended with great risk. It is absolutely necessary to a perfect working of the clock, that the endless screw should fit accurately the centre of the hour circle thread, which may be ascertained by the escape lever raised to its greatest elevation, and used as a feel lever, (lever of contact,) and effected by the screw *c* and reaction spring, so that they have no play together.

A clamp and tangent screw *r* to the declination circle may be turned from either direction, the ends of the screw being made square, to receive the keys of Hook's joint handles reaching to the observer.

The instrument is furnished with a repeating filar-micrometer with a circle divided on silver, and reading by two verniers to minutes of arc, and two parallel spider lines revolving with the verniers in a plane perpendicular to the circle. One of the wires is connected with a micrometer screw, whose head is divided into 100 parts, and the other, with a milled-head screw, for the adjustment of the line of collimation. Its wires are illuminated by small lamps fitting into the tubes *s s*, or the field is illuminated by a similar lamp, through an aperture in the tube and diagonal reflector, enabling the observer to have bright lines and dark field, or bright field and dark lines, at will; and the quantity of light is controlled by the interposition of frames, holding fine tissue paper, and sliding through spaces in the lamps. To the micrometer there are eight eye pieces, with magnifying powers extending from 100 to about 1,000 times.

There are two annular micrometers with different magnifying powers, one having a single and the other a double ring, and five ordinary eye pieces, with powers from 150 to 750 times; three small brass lamps for illuminating, and all other necessary tools for mounting and adjusting it.

The preceding outline of this grand instrument has been given in the order in which its various parts were put together, in which I was assisted by four laborers. Between those parts *of brass* which worked together, there was placed a due quantity of mutton tallow, that had been rendered in a clean earthen vessel, and between *steel and brass* fine olive oil.

The lamps have been found inconvenient, every change of position requiring the attention of the observer, to prevent the oil running down on the wick and extinguishing the light, and escaping whenever they are set down, before or after use. It is a matter of some surprise that the Germans should have continued satisfied with this construction, when a lamp may so easily be made that will remain vertical in every position of the telescope.

It would be unjust to say that the optical powers of the instrument were fully tested whilst it remained under my charge; but, as a promise of what it can do hereafter, I may mention that it has shown the companion to *Polaris* when the sun was full fifteen minutes *above the western* horizon. The cost of this telescope was $6,000; its object glass, alone, being valued at $3,600.

THE OBSERVING CHAIR.

Plate VI

An observing chair has been made for the equatorial by Messrs. T. W. & R. C. Smith, of Alexandria, District of Columbia, to whom I am indebted for the following account of it: A plan was furnished by myself, but it is due to these artists to state that their modifications have almost entirely superseded the original design, and the observer may move himself in any required direction, with a facility which could not have been attained in the other mode. As its construction is entirely original, the working of its various parts could not be absolutely predetermined, and alterations were found necessary, to perfect its motions, which have made the cost greater than the sum at which they stipulated to complete it, viz: $225. Whilst I greatly regret that they experience pecuniary loss in making this chair, I have strong faith that their reputation as ingenious and successful engineers will be greatly enhanced by it, for I know of no contrivance of like excellence in any observatory.

"The chair has three movements: 1st. Around the dome on two circular rails, the inner of which fits the grooved wheels A A, in order to guide the lower frame B. The outer wheels A A are adapted to a plain rail, and the frame B is moved by the friction of one of these; the motion to which wheel A is communicated by a cord O passing round the pulley M, under the pulleys N N, and over the tightening pulley L, so as to be within reach of the observer's hand, at whatever elevation the chair is placed. The pulley M is connected with the wheel A by gearing.

"2d. That of the cast-iron frame C, to and from the centre of the dome. This is upon rails screwed to the lower frame B, on which it rolls, guided by the flange wheels D, D, D, D. Motion is given to this frame by the cord R passing round the pulley P, which is geared to the shaft of a pair of the flange wheels D D, whose friction carries the frame C in and out.

"3d. Vertical motion. The chair is secured permanently to the cross bar F, which slides up and down in grooves on the inside of iron uprights E E. It is counterpoised (with the observer seated) by the weights G G connected with the chair bar F, by cords X X, passing over pulleys W W at the head of the uprights. S is a pinion shaft for raising and lowering the chair. Two pinions on this shaft gear into the racks I I, and this shaft is turned by the levers H K. On K are two palls working on two ratchet wheels, fastened to the pinion shaft S, and having their teeth in opposite directions. When one of these palls is in gear, the other is thrown out. T is another ratchet wheel, fastened on the pinion shaft S, on which works a catch attached to the chair bar F, and which catch drops on the ratchet, so as to prevent the chair from flying up when the observer leaves his seat.

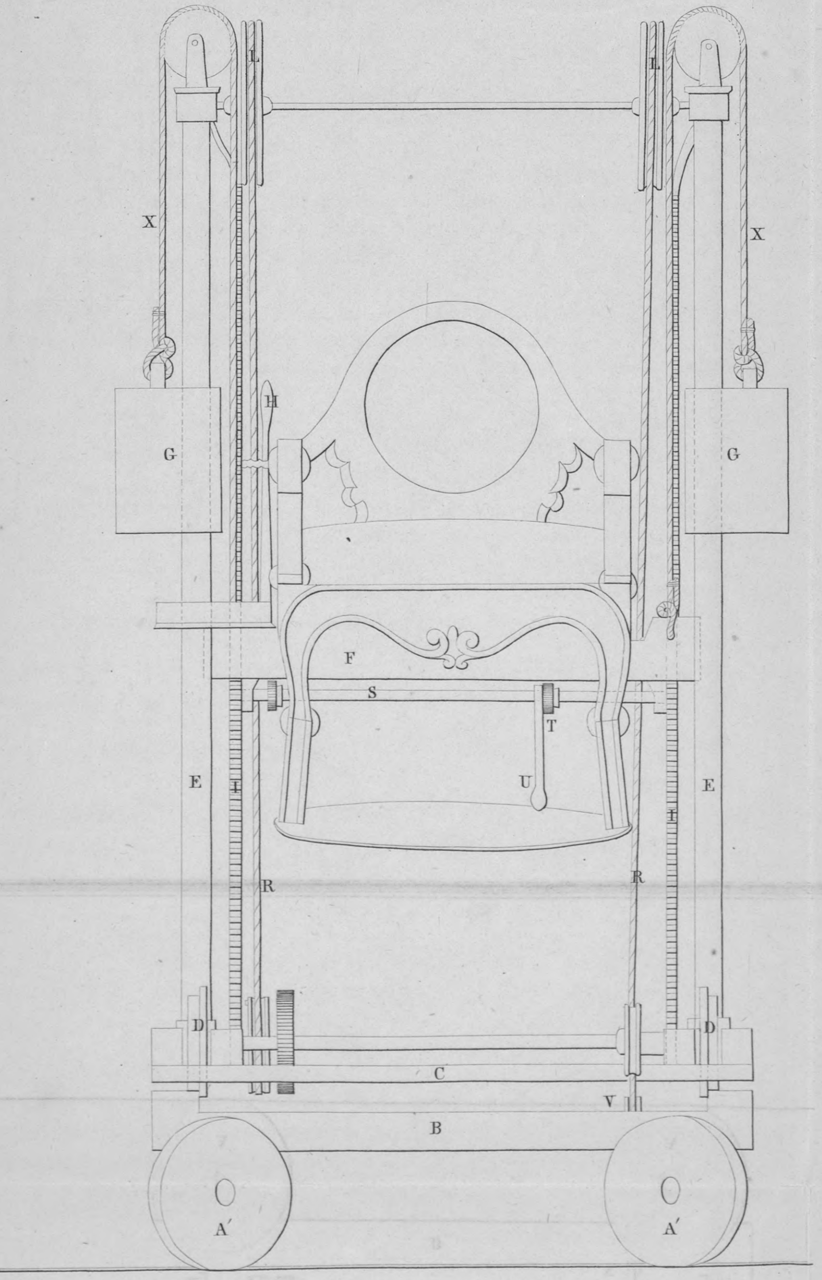
"Before the chair can be elevated, the observer must place his foot on the treadle U, to raise the catch out of gear."

Additional weights have been supplied by the makers, to introduce beneath the seat of the chair, should that of the observer be overbalanced by the counterpoises.

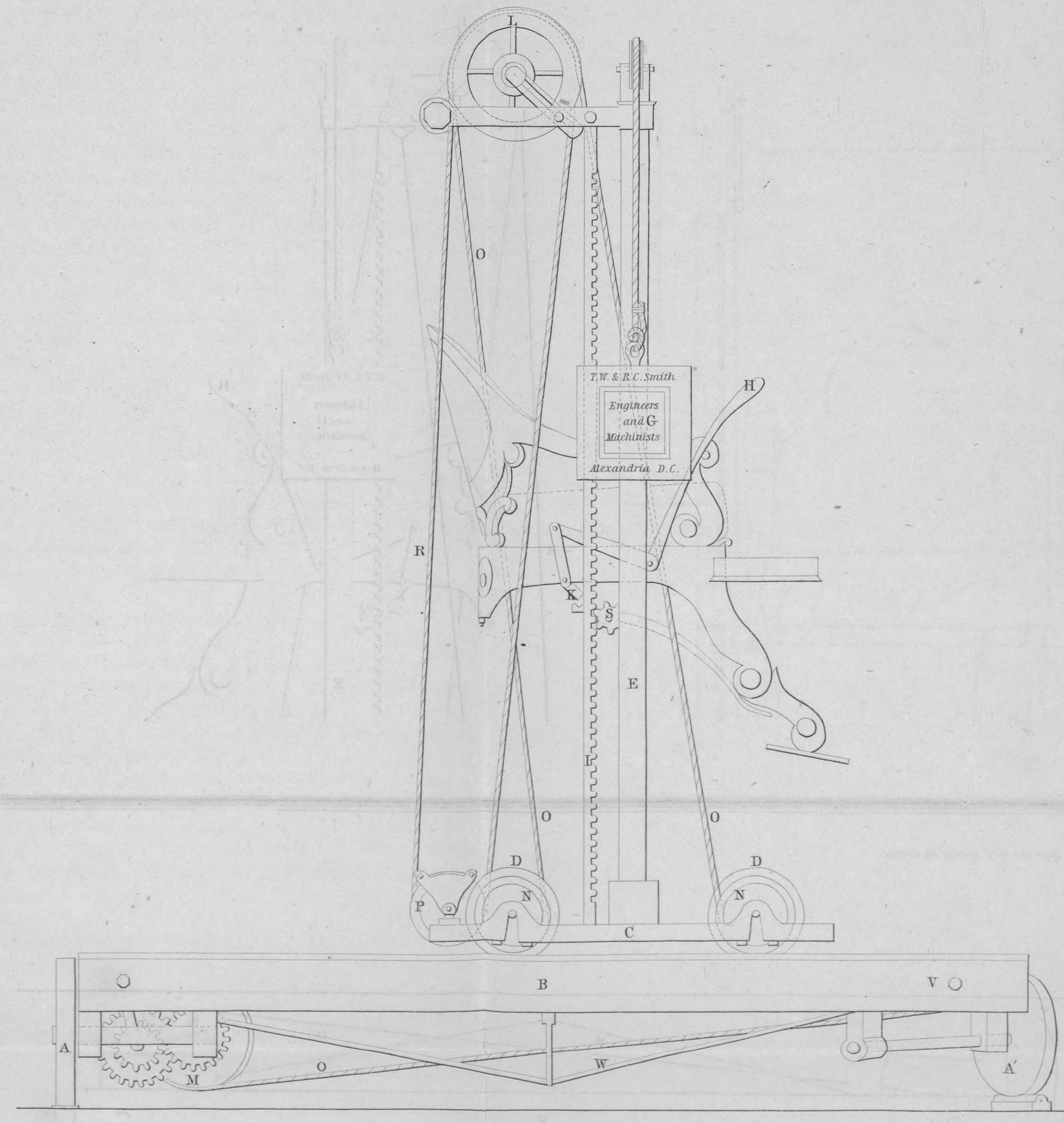
PLATE VI

Scale one inch to the foot

Front View



Side View



Drawn by Allexey Von Schmidt.

ENUMERATION OF PARTS OF THE CHAIR.

A, AA′ A′.—Four wheels on which the lower frame B is supported.

B.—Lower frame of wood.

C.—Cast-iron frame.

D D D D.—Four flange wheels, supporting cast-iron frame, and travelling on rails of lower frame.

E E.—Strong iron uprights, fitting in sockets of the frame C, intended to support and guide the chair.

F.—Iron cross-bar, to which the chair is secured.

G G.—Counterpoises of cast iron, sliding on the uprights.

H.—Lever for raising and lowering chair.

I I.—Iron racks for raising and lowering chair.

K.—Lever for raising and lowering chair.

L L.—Tightening pulleys of wood, around which cords pass, to give circular and radiating motions.

M.—Pulley geared into one of the outer wheels A of the frame B.

N N.—Guide pulleys for cord O, for which a second guide pulley is at V.

P.—Pulley geared into the flange wheels D D, to give radiating motion to the cast-iron frame by the cord R.

S.—Pinion shaft for raising the chair.

T.—Ratchet wheel on shaft S, to prevent the chair from flying up.

U.—Treadle for raising the catch off the ratchet T.

W.—Iron brace to strengthen the frame B, and prevent flexure.

ADJUSTMENTS OF THE EQUATORIAL.

AUGUST 15, 1844.

Directed the telescope to α *Canis Major*, (Sirius,) whose declination was 16° 30′ 21″ south, and observed the intervals of time occupied in passing from the movable to the stationary wire of the micrometer, the two wires being accurately *eleven* revolutions of the micrometer head apart.

First series.	First series.
″	
12.0	11.8
11.6	11.5
11.8	11.8
11.6	11.7
11.1	11.7

Mean of ten observations - - - 11″.66

The wires were then separated to *twenty* revolutions.

Second series.	Second series.
″	″
21.4	21.4
21.3	21.2
21.3	21.3
21.3	21.3
21.2	21.3

Mean of ten observations - - - 21″.30

The telescope was then directed to α *Canis Minoris*, (Procyon,) whose declination was 5° 37′ 07″ north; the distance of the wires remaining as in last series, *twenty* revolutions.

Third series.	Third series.
″	″
20.4	20.6
20.6	20.7
20.4	20.7
20.8	20.7
20.4	20.5

Mean of ten observations - - - 20″.58

Multiplying these intervals respectively by the cosine of the star's declination, the angular values at the equator obtained are:

	′
First series, eleven revolutions - - - -	167.70
Second series, twenty revolutions - - -	306.34
Third series, twenty revolutions - - - -	307.22
Sum, fifty-one - - - - - - arc	781.26

$$\text{Whence, one revolution} = \frac{781''.26}{51} = 15''.319$$

AUGUST 29, 1844.

The following stars were observed, for ascertaining the instrumental errors, the times being corrected for the error of the chronometer. Barometer 30.030 in. Temperature, 71°.0.

Star.	Face of circle.	Sidereal time.	Hour circle.	Observed N. P. D.
		hs. ms. secs.	hs. ms. secs.	
α Hydræ - -	E	9 00 50.6	11 41 01.0	
Do. - -	W	9 12 20.7	11 52 32.7	
Do. - -	E	9 19 48.8	0 00 00.0	
δ Ophiuchi -	W	16 12 58.8	0 06 51.0	
Do. - -	E	16 19 09.7	0 13 00.5	° ′ ″
α Ursæ Major -	W	16 54 04.0	6 00 00.0	27 23 49.0
ε Ursæ Minor -	W	16 59 00.0	0 00 00.0	7 44 07.0
Do. - -	E	17 04 00.0	0 00 00.0	7 44 40.0

		° ′ ″	
ε Ursæ Minor - -		7 44 07.0	west.
		7 44 40.0	east.
Diff. - -		0 00 33.0	
½ diff.—Index error		0 00 16.5	add circle west.

		° ′ ″	
ε Ursæ Minor - -		7 44 07.0	west.
Index error -	+	0 00 16.5	
Refraction -	—	0 00 52.8	
Instrumental -		7 43 30.7	N. P. D.
Nautical Almanac		7 42 40.7	N. P. D.
Polar axis -		0 00 50.0	low.

		° ′ ″	
Ursæ Major -	-	27 23 49.0	west.
Index error	- +	00 00 16.5	
Refraction	- +	00 00 30.8	
Instrumental	-	27 24 36.3	N. P. D.
Nautical Almanac		27 24 43.7	N. P. D.
Polar axis	-	00 00 07.4	west.

	Time. h. ′ ″		Hour circle. h. ′ ″	
δ Ophiuchi - - -	16 12 58.8	- - -	0 06 51.0	west.
	16 19 09.7	- - -	0 13 00.5	east.
	00 06 10.9		0 06 09.5	
	00 06 09.5			
	00 00 01.4			
Error of collimation	00 00 00.7	add circle east.		

	Time. h. ′ ″		Hour circle. h. ′ ″	
α Hydræ - -	9 00 50.6	- - -	11 41 01.0	east.
	9 12 20.7	- - -	11 52 32.7	
	0 11 30.1		00 11 31.7	
			00 11 30.1	
			00 00 01.6	
Error collimation : add circle east		-	00 00 00.8	

Telescope west of the pier, and directed to α Hydræ, the hour circle reading 0h. 00′ 00″ exactly.

		h. ′ ″	
α Hydræ - -	-	9 19 48.8	
Collim. - -	- —	0 00 00.8	
Polar axis -	- +	0 00 00.5	
		9 19 48.5	
True sidereal -	-	9 19 57.0	time.
Inclination hour -	-	0 00 08.5	circle verniers.

In attempting to level the frame supporting the instrument, (and to which the verniers of the hour circle are secured,) I found that the effect of screws 1 and 2 was to bend it about the centre, without accomplishing the desired object; and, as there was not sufficient adjustment to the verniers themselves, I dismounted the instrument to ascertain the cause. It was found that the makers, in tapping the bed-plate for the screw 4, had bulged it out on the west side, and overlooked it in the final fitting. This would not have been of consequence had the pier been accurately in the meridian; but as its deviation is about 5' to the west, the instrument was nearly at the limit of its adjustment towards the east, and hence the difficulty. The inequality being filed off, the telescope was remounted on the 5th September.

The want of a wire for differences of right ascension, whilst measuring differences of declination, having been much felt, this occasion was taken to have one added to the filar-micrometer, at right angles to the other two. This was performed by Mr. Wurdeman, at the office of the coast survey.

In the following observations, the polar distance was occasionally observed with this last, which I shall call T, or transit wire, to distinguish it from M, or micrometer wine, and the difference of their *index errors*, or collimation in altitude, is shown in the result :

Date.	Star.	Circle.	Wire.	Time.	Hour circle.	Observed N. P. D.	Barometer.	Temperature.
				h. m. secs.	h. m. secs.	° ' "	inches.	° '
Oct. 4	α Aurigæ -	E	M	23 05 00.0	6 00 00.0	44 10 00	29.776	51 6
5	β Ursæ Minor	W	M	20 57 00.0	6 00 00.0	15 10 40	29.896	58 5
5	α Cephei -	E	M	21 10 00.0	11 56 00.0	28 05 10		
5	Do. -	W	M	21 20 00.0	0 06 00.0	28 05 05		
7	α Aurigæ -	E	M	23 05 00.0	6 00 00.0	44 10 00	30.178	42 0
8	α Cephei -	W	M	21 00 00.0	11 45 00.0	28 05 26	30.150	48 0
8	Do. -	E	M	21 07 00.0	11 53 00.0	28 05 40		
8	Do. -	E	M	21 14 00.0	0 00 00.0	28 05 28		
8	Do. -	W	M	21 20 00.0	0 06 00.0	28 05 24		
8	β Ursæ Minor	W	M	21 27 00.0	6 30 00.0	15 10 36		
8	β Cephei -	E	T	21 31 00.0	0 01 00.0	20 04 22		
8	Do. -	W	T	21 35 00.0	0 05 00.0	20 12 24		
8	Do. -	W	T	21 40 00.0	0 10 00.0	20 12 24		
8	Do. -	E	T	21 43 00.0	0 13 00.0	20 04 20		
8	α Aquarii -	E	T	21 50 34.5	11 49 53.5	90 59 56		
8	Do. -	W	T	21 54 53.0	11 54 18.3	91 07 52		
Moved the micrometer wire west three revolutions :								
Oct. 8	α Aquarii -	W	T	22 01 46.5	0 01 08.0	91 07 48		
8	Do. -	E	T	22 06 20.7	0 05 43.8	90 59 54		
8	γ Cephei -	E	T	23 26 57.5	11 51 50.5	13 11 42		
8	Do. -	W	T	23 31 01.0	11 55 45.5	13 19 36		
8	Do. -	W	M	23 34 00.0	11 58 00.0	13 15 34		
8	Do. -	E	M	23 37 00.0	0 01 00.0	13 15 24		

The apparent polar distances of the preceding stars, as given in the Nautical Almanac, on the respective days, are as follows :

			°	'	"
α Aurigæ	October 4th	- -	44	10	07.3
Do.	October 7th	- -	44	10	07.0
β Ursæ Minor	October 5th	- -	15	12	27.9
Do.	October 8th	- -	15	12	28.9
α Cephei	October 5th	- -	28	03	51.1
β Cephei	October 8th	- -	20	06	48.7
α Aquarii	October 8th	- -	91	04	03.9
γ Cephei	October 8th	- -	13	13	46.9
α Cephei	October 8th	-	28	03	50 5

The *index erros* of the declination circle, or collimation in altitude, is found by taking half the difference of the observed polar distances of the same star—instrument east and west. The observations being circum-meridian, the change of refraction due to change of altitude is inappreciable.

The elevation of the polar axis is obtained by taking half the sum of the observed polar distances of the same star—instrument east and west—and, after correcting it for refraction, applying the apparent polar distance from the Nautical Almanac. If the star is above the pole, and the instrumental exceeds the apparent polar distance, the pole of the instrument is below the pole of the heavens.

The deviation of the polar axis from the meridian is found by observing the polar distance of a star whose hour angle is 6 hours; correcting it for *refraction in polar distance*, and applying the apparent polar distance from the Nautical Almanac. If the star is to the east of the meridian, and the instrumental exceeds the apparent polar distance, the pole of the instrument is to the west of the celestial pole. The refraction in N. P. D. may be found by the formula—

$$R = (r \sin. L, \sec. A, \text{co-sec. } \pi) - (r \text{ tang. } A, \text{co-tang. } \pi)$$

in which, r = refraction in altitude;
L = latitude of observatory;
A = altitude of the star;
π = polar distance of the star.

The error of *collimation in azimuth* is obtained by observing the transits of an equatoral star over the micrometer wire, with the instrument alternately east and west, and noting the time by a sidereal clock, as well as the hour circle readings in each position. *One-half the difference* of the intervals, as measured by the clock and hour circle, will be the error of collimation, and it is additive to the *readings* of the hour circle *instrument* east, when the interval shown by the circle is greater than the clock interval, and the first transit was observed with the instrument in that position.

For a star out of the equator, the error thus determined must be multiplied by the secant of its declination.

The declination and polar axes are intended by their construction to be placed at right angles to each other, but the observations seem to indicate a small *inclination.* The transits of a close circumpolar star being observed with the instrument east and west alternately, and the hour circle readings corrected for the error of collimation, one-half the difference of the intervals of the clock and circle readings corrected, multiplied by the tangent of the star's polar distance, will be the inclination of the axes in parts of the equator. As this error varies as the co-tangent of the polar distance, for any star out of the equator, it must be multiplied by that co-tangent, and the correction is additive to the hour circle *readings, instrument* east, when the circle is west at the first transit and its interval less than the observed time.

In reducing the observations, Bessel's refractions have been made use of, and for greater convenience the instrument is assumed to be in one position, viz: west, and consequently the declination circle *east*, the signs of the corrections being changed where necessary. They give the following positions of the instrument:

Star.	Index error T.	Index error M.	Refraction.	Polar axis low.	Polar axis west.	Collima. azimuth.	Inclin.
	′ ″	″	″	″	″	″	″
α Aurigæ -	....	....	+ 55.7	....	48.5		
β Ursa Minor -	....	....	+ 14.9	....	90.5		
α Cephei -	....	— 2.5	— 24.4	52.0			
α Aurigæ -	....	....	+ 57.7	....	48.2		
α Cephei -	....	— 7.0	— 25.1	67.4			
Do -	....	— 2.0	— 25.1	60.4			
β Ursa Minor -	....	....	+ 25.9	....	84.5		
β Cephei -	+ 4 01.0	....	— 35.3	59.0			
Do -	+ 4 02.0	....	— 35.3	58.0			
α Aquarii -	+ 3 58.0	....	+ 49.3	39.4	....	+ 3.15	
Do -	+ 3 57.0	....	+ 49.3	36.4	....	— 0.80	
γ Cephei -	+ 3 57.0	....	— 45.6	66.5	....	....	— 0.18
Do -	....	+ 5.0	— 45.6	56 5			
Means -	+ 3 59.0	— 1.6	-	55.1	67.9	— 0.80	— 0.18

Observations near the equator give a smaller depression to the polar axis than those near the pole; and those east of the meridian a less deviation than those west of it, which would arise from an excentricity of the declination circle. Previous observations, since reduced, accord in like discrepancies, but I would be unwilling to render injustice to the makers, by judgment on the small number which I have made. The duty of minute examination properly belongs to those who are to use the instruments—the province allotted to myself has simply been to place them in approximate positions.

In the adjustment of this, as well as the other instruments, I beg to acknowledge my obligations for the voluntary assistance of Professor Coffin, U. S. N., who was desirous to obtain knowledge of their manipulation, and brought great zeal and ability to the undertaking.

THE TRANSIT INSTRUMENT.

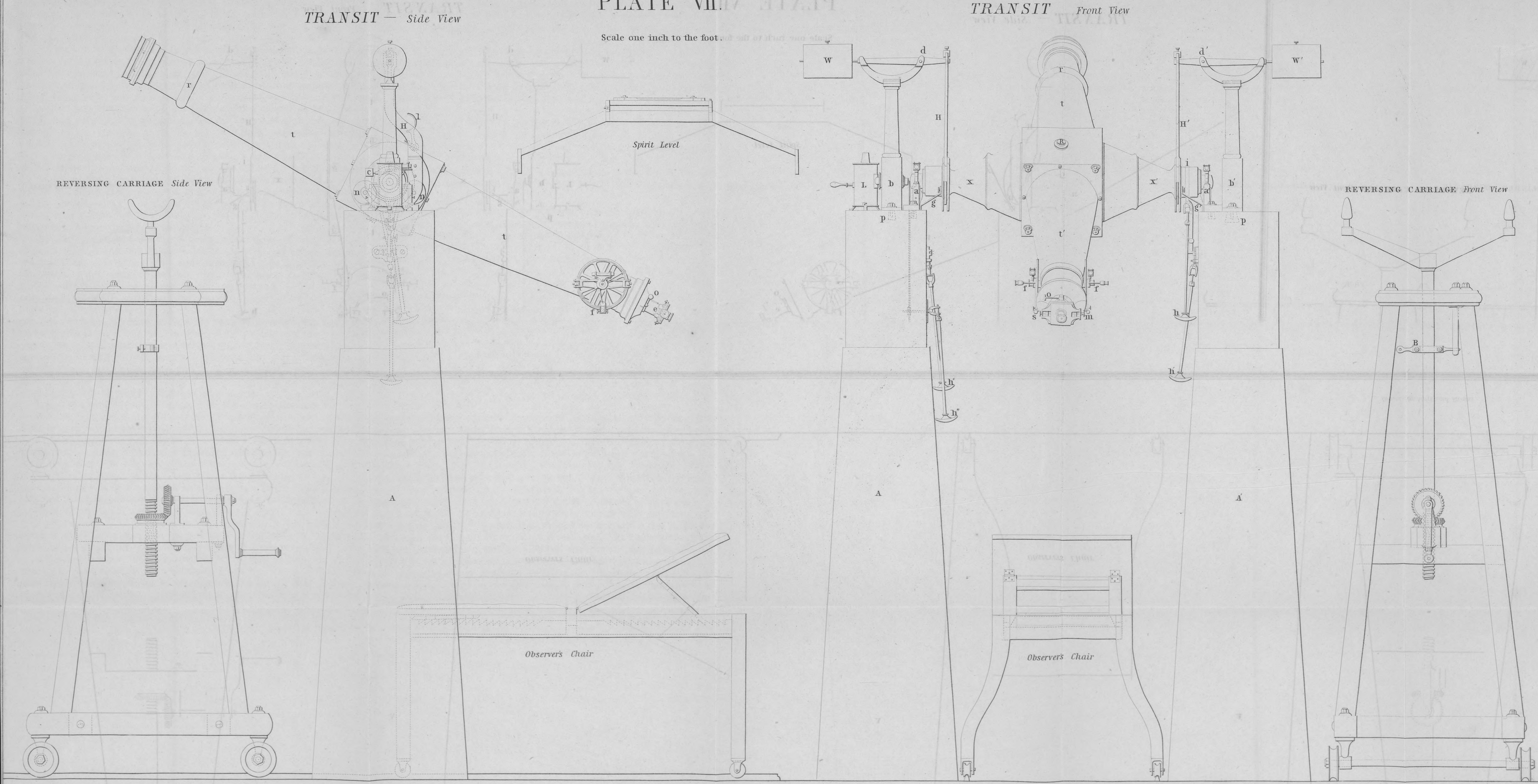
Plate VII.

An object glass, with a clear aperture of 5½ inches and focal length 88 inches, was obtained from Messrs. Merz & Mahler, and the instrument was constructed by Ertel & Son, at Munich. Together with the reversing carriage it filled two large cases, and arrived at the same time as the equatorial. On opening them, the metallic portions were found entirely covered with moisture, the steel work of the reversing carriage being greatly rusted, and several specks showing upon the pivots of the transit axis. To check oxidation of the latter, the transit was immediately removed from the box, and well dried, the pivots being carefully rubbed with soft dry woollen cloth.

It was accompanied by a small iron rod, cut to a length equal to the distance at which the Y's *a a'* were to be placed apart, and a notch on each end showed the interval necessary between the inner faces of the piers A A.' The Y's are of brass, of the usual construction, *a* having an adjustment for azimuth, and *a'* for level of the axis. They are secured to the piers by two strong steel screws and plugs to each; the latter cemented in cavities *p p* cut for them, with a preparation similar to that used in put-

PLATE VII.

Scale one inch to the foot.



Drawn by Strickland Kneass

ting up the equatorial. The columns *bb* are also of brass, and fastened in the same manner, the steel screw heads and plugs showing plainly in the drawing. The axis of the transit $x\ x'$ is of red metal, 42 inches long between its bearing points. It has been cast in one piece, of great strength, and terminates in pivots of fine steel, firmly screwed to a shoulder within the red metal. Steel springs attached to the Y's press against the shoulders, and keep the axis properly in place. The pivots have been turned down with diamond tools, leaving a projecting band half an inch wide and five hundredths of an inch thick, for the immediate bearing surfaces upon the Y's. Their form may be examined by the small transverse levels placed with their counterpoises *c*, so that a brass pin attached to one end of the level is in contact with the most elevated point of the projecting band throughout the revolution of the pivots. *Both* pivots and the axis are hollowed for the purpose of illumination; the light from the lamp L passing through the base of the column *b*, to a diagonal reflector within the cubical box, whence it is thrown to the eye end of the tube. It is intended that the lamp shall always occupy the same position; and when the transit is reversed, the reflector is turned through 90° by means of the milled-head R, or the field may be darkened by the same process when it is desirable to illuminate the wires for faint objects, through an aperture which will be mentioned presently.

The telescope is formed of two conic frustums $t\ t'$ of stout brass, united with the cubical box, which is the centre of the axis, by steel screws. The band of brass *r* is intended as a counterweight to the finder circles *f f*, and the cones being symmetrical, the object and eye ends may be readily transposed; the cell containing the object glass and the eye end requiring only that the screw heads holding them be slightly loosed.

There are two circles eight inches in diameter for finders. These are divided on bands of silver, inlaid; are read by two verniers each, to 10″, and are furnished with levels, eye pieces for reading, clamps, and tangent screws—the latter acting against steel springs, to avoid "*losing time.*" By loosing the screws at their centres, the position of the finders with reference to the 0° and optical axis of the telescope, admits of slight adjustment; and the eye *tube* sliding within the telescope, may be adjusted to celestial focus by first liberating the clamp *o*.

Just in advance of the eye piece, there is a small glazed aperture, opened by turning the band *c*, through which light may be admitted to the wires from a lamp held in the hand, and leaving the field dark, as just mentioned. The diaphragm contains seven vertical and two horizontal permanent wires, and a movable vertical wire, fitted with a micrometer screw and divided head *m;* and the eye piece, placed in a dovetailed slide, is moved perpendicular to each of the wires by the milled-head screw *s*.

Grooves turned in the transit axis receive friction rollers *n*, which are attached to the supporting hooks H H′; and the great weight of the instrument is relieved from the Y's by counterpoises W W′ and levers, having their fulcra at *d d*. The hooks are kept steady by pieces of brass $g\ g'$ screwed to the Y's and milled-head screws, fastening them together; these latter being kept loose when the instrument is not in use.

A collar *i*, with a tail piece, works with little friction round one extremity of the axis, and has a clamping screw connected with the Hook's joint handle *h*. The tail piece is intended to transmit slow motion; and, to that end, passes between two screws of a slide moving horizontally; the brass plate holding the slide being secured by screws and plugs cemented in the inner face of the pier. Motion is given by a second Hook's joint handle *h*, connected with a screw turning vertically against a small brass wedge, and which, in its turn, moves the slide and tail piece. If the collar be clamped, the telescope may thus be made to describe a small arc in either direction—a spring, pressing against one of the screws beside the tail piece, forcing back the wedge and slide when the handle is turned in an opposite direction. There being but one clamp, h'' is intended for use upon the reversal of the instrument; h''' works a pinion and rod, with a rack at its lower end, the upper having a socket holding a colored glass wedge, used to moderate the light of the lamp by interposition.

The level is of the ordinary riding kind, as shown in the drawing, its tube being nearly filled with *sulphuric ether*. In its present construction, this liquid is scarcely suitable for the climate; the low temperature at which it boils frequently expanding it in summer, so as to fill the tube and force out the discs of glass with which the ends are closed, and in winter the bubble is inconveniently elongated. When upon the axis, the level is kept steady by the brass hook *l;* but this permits too much play, and the instrument (level) will be defective, until a small transverse level is added, to insure readings in the same vertical plane.

For examining its line of collimation, the transit is accompanied by a reversing carriage, of which a front and side view is drawn. It travels on an iron railway, let into the floor between the piers, as does also the observing chair. The vertical shaft, arms, and wheels, of the former, are of polished iron or steel, and the remainder of the carriage of wood, veneered with beautiful specimens of "curled ash;" the parts of the arms which receive the transit axis being cushioned with morocco leather. To reverse the instrument, the carriage is moved under it, and the crank turned till the cushions touch the axis; the hooks, with the friction rollers, are then secured by the milled-head screws of the pieces $g\ g'$, the instrument raised out of the Y's by the crank, and rolled out with the carriage till clear of the piers, when it may be reversed, the arm B allowing it to be turned through just 180°. The investigation of this error, by reflecting the system of wires from a basin of mercury, is a much preferable mode, as it avoids the injury to which the instrument is exposed in reversal, and the absolute certainty of changing its position in level and azimuth. Besides these advantages, the observer may test the adjustment at all times, which he cannot do in the old method, even if he use collimators.

The mechanical execution of the instrument reflects much credit on the makers; the only advantageous additions that they could have made (as my little experience with it has pointed out) being the transverse level, and a reserve chamber at one end of the tube, to prevent destruction in summer, and control the length of the bubble; and the only omissions perceived are—the Hook's joints are too large for the thickness of the plates, requiring the stone to be cut away for them, and the brass rod holding the colored glass wedge is two inches too short.

They have furnished with it, four astronomical eye pieces, with different magnifying powers; colored shades for the sun; six extra level tubes for different parts of the instrument, and tools of every description for mount- and adjusting it.

In addition to the chair for the observer, of which a front and side view are given, I have had a movable flight of steps made for each pier, and of the same width, to facilitate adjustments of the instrument.

Its cost, including reversing carriage and packing, was $1,480; the object glass alone, $320.

ADJUSTMENTS OF THE MERIDIAN TRANSIT.

OCTOBER 5, 1844.

Attached the collimating eye piece, placed a basin of mercury below the instrument, and turned the transit to a vertical position, the object glass being downwards. The image of the wires reflected from the surface of the mercury was found to coincide exactly, with the wires seen directly.

The verniers of the *finder* circles were set to 0°, and the two horizontal wires made to cover their reflected image, by moving the transit in the meridian; the bubbles of the levels to the finders being then brought to the centre of their tubes, the collimation in altitude was corrected.

The collimation in azimuth *being equal to the inclination of the axis*, when the wires and their images coincide, a careful levelling was immediately made, as follows:

Object glass south, telescope horizontal, and temperature 62°.

East end.		West end.
29.6		30.2
29.7		29.9
29.4		30.1
29.4		30.0
29.4		30.0
	Level reversed.	
34.5		24.7
34.5		24.7
34.5		24.7
34.5		24.7
34.5		24.7
Sum 320.0 east		Sum 273.7 west.
Sum 273.7 west		
20)46.3 difference.		
div. 2.31 east end of axis elevated.		

The error of collimation is therefore — 2.31 div. of the level, which is equal to — 2''.102 arc.

OCTOBER 7, 1844.

Screwed the Y's down to the piers more firmly; and a change of level being produced amounting to 2.5 divisions, the elevating screws were altered.

The following transits were observed by a sidereal chronometer, whose rate during the succeeding 24 hours was + 4''.00, and is assumed to have been uniform throughout the observations:

Star.	I.	II.	III.	IV.	V.	VI.	VII.	Mean.
	″	″	″	′ ″	″	″	″	h. ′ ″
α Cygni - -	......	04.4	24.6	40 45.3	05.6	25.8	46.1	20 40 45.140
61′ Cygni - -	38.3	56.5	15.0	04 33.0	51.4	09.7	28.2	21 04 33.157
ζ Pegasi - -	36.8	51.4	06.2	38 20.8	35.4	50.2	04.6	22 38 20.771
α Piscis Aus. -	51.2	07.8	24.9	53 41.7	58.4	15.2	32.0	22 53 41.600
α Ursæ Major* -	06.5	38.2	10.0	58 41.7	13.5	45.2	16.8	22 58 41.700
γ Cephei - -	34.8	38.0	41.3	37 44.4	47.6	50.8	54.0	23 37 44.414
α Androm. - -	11.3	27.4	44.2	05 00.6	17.0	33.3	49.8	0 05 00.514
γ Pegasi - -	08.0	23.0	38.0	09 53.0	08.0	22.8	37.8	0 09 52.943
α Cassiopeæ -	06.3	32.0	57.5	36 23.3	49.0	14.8	40.0	0 36 23.271
β Ceti - -	40.3	55.1	10.6	40 26.1	41.5	56.6	11.6	0 40 25.971
Polaris - -	–	–	–	09 00.0	–	–	–	1 09 00.000

At 7 hours sidereal time, the transit instrument was levelled, its tube being horizontal; object glass south, and temperature 54°.5.

East end.	West end.
36.0	34.7
36.0	34.7
36.0	34.7
36.0	34.7
36.0	34.7
Level reversed.	
32.7	37.7
32.7	37.7
32.7	37.7
32.7	37.7
32.7	37.7
Sum 343.5 east	Sum 362.0 west.
	Sum 343.5 east.
	20)18.5 diff.
	div.
West end elevated - - - - -	0.92

and the value of one division of the level, as given by Ertel & Son, being 0″.91 arc nearly, the error of level equals 0″.837 arc; or converting it into time, that it may be applied to the preceding observations, it becomes—

Error of level - - - - - - - - +0″.056
Error of collimation 2″.102÷15 = - - - - —0″.140
Rate of chronometer - - - - - - +4″.000

Correcting the mean times of transit for the errors of level and collimation by the formulæ—

$I = 0''.056 \cos. (\pi - \lambda) \text{ co-sec. } \pi$ - - - - - I
$\Gamma = 0''.140 \text{ co-sec. } \pi$ - - - - - - - II

π being the polar distance of the star, and λ the co-latitude of the observatory = 51° 06′ 20″ nearly; and applying the rate so as to reduce all the observations with the absolute error, at the time of transit of α *Cygni*, the subjoined values are obtained:

* α Ursæ Major sub polo.

Star.	Mean times.	I.	Γ.	Rate.	Times corrected.
	h. ′ ″	″	″	″	h. ′ ″
α Cygni - -	20 40 45.140	+ .078	— .193	....	20 40 45.025
61′ Do - -	21 04 33.157	+ .071	— .178	— .066	21 04 32.984
ζ Pegasi - -	22 38 20.771	+ .050	— .142	— .327	22 38 20.352
α Piscis Aus. -	22 53 41.600	+ .023	— .162	— .368	22 53 41.093
α Ursæ Major S. P. -	22 58 41.700	— .024	+ .304	— .382	22 58 41.598
γ Cephei - -	23 37 44.414	+ .193	— .612	— .491	23 37 43.504
α Andromedæ -	0 05 00.514	+ .062	— .159	— .566	0 04 59.851
γ Pegasi - -	0 09 52.943	+ .052	— .144	— .579	0 09 52.272
α Cassiopeæ - -	0 36 23.271	+ .095	— .248	— .655	0 36 22.463
β Ceti - -	0 40 25.971	+ .032	— .148	— .666	0 40 25.189
Polaris - -	1 09 00.000	+ 1.372	— 5.290	— .746	1 08 55.336

The apparent right ascensions of these stars at transit over the meridian of Washington, on the 7th of October, 1844, (the day of observation) as given in the Nautical Almanac, are—

	h. ′ ″
α *Cygni* - - - - - -	20 36 09.894
61′ *Cygni* - - - - - -	20 59 58.265
ζ *Pegasi* - - - - - -	22 33 45.208
α *Piscis Aus.* - - - - - -	22 49 05.578
α *Ursæ Major* - - - - - -	10 54 04.584
γ *Cephei* - - - - - -	23 33 08.362
α *Andromedæ* - - - - - -	00 00 24.870
γ *Pegasi* - - - - - -	00 05 17.130
β *Cassiopeæ* - - - - - -	00 31 47.550
α *Ceti* - - - - - -	00 35 49.780
Polaris - - - - - -	01 04 30.771

Taking the difference between the *corrected times* of any two of the preceding stars, the difference of whose polar distance is not less than 40°, from the difference of their tabulated right ascensions, the azimuthal deviation may be computed by the formula—

$$\triangle = \text{D. sin. } \pi \text{ sin. } \pi' \text{ co-sec. } (\pi \pm \pi') \text{ sec. L} \quad \text{- - - - - - III;}$$

in which,

D, = difference times, minus difference right ascensions;

π and π', = polar distances of the stars;

L, = latitude of the observatory.

Combining many pairs of these stars, the following deviations are obtained. From—

		″
α *Cephei and* α *Ursæ Major* - - - -	*West*,	0.389
α *Ursæ Major and Polaris* - - - -	"	0.403
α *Andromeda and Polaris* - - - -	"	0.360
γ *Pegasi and Polaris* - - - -	"	0.362
β *Ceti and Polaris* - - - -	"	0.365
α *Cygni and Polaris* - - - -	"	0.353
61′ *Cygni and Polaris* - - - -	"	0.353
ζ *Pegasi and Polaris* - - - -	"	0.362
α *Piscis Aus. and Polaris* - - - -	"	0.367
α *Cassiopeæ and* β *Ceti* - - - -	"	0.353
α *Cassiopeæ and Piscis Aus.* - - - -	"	0.377

α *Cygni and* α *Piscis Aus.*	- - - -	*West,*	$0''.313$
ζ *Pegasi and* α *Piscis Aus.*	- - - -	"	0.624
α *Androm. and* α *Piscis Aus.*	- - - -	"	0.610
γ *Pegasi and* α *Piscis Aus.*	- - - -	"	0.569
Mean △	- - - -	"	0.391

The correction to be applied to each star will be—

$$\triangle' = 0.391'' \sin. (\lambda - \pi) \text{ co-sec. } \pi;$$

the notation being as before, and the quantities thus obtained subtractive from the *corrected times* of all stars sub-polo and south of the zenith, and additive to those above the pole and north of the zenith.

The equatorial intervals of the wires, computed from these observations, are—

Means, 14''.368, 14''.578, 14''.500, 14''.486, 14''.445, 14''.416;
and from a mean of five complete transits of ε *Ursæ Minoris,* three of ζ *Ursæ Minoris,* one of β *Ursæ Minoris,* and two of γ *Draconis,* previously observed—

Means, 14''.499, 14''.452, 14''.523, 14''.521, 14''.463, 14''.459;
from which we obtain the intervals from the—

		sec.
First to the fourth wire	- - - - -	43.460
Second to the fourth wire	- - - - -	29.026
Third to the fourth wire	- - - - -	14.511
Fifth to the fourth wire	- - - - -	14.503
Sixth to the fourth wire	- - - - -	28.958
Seventh to the fourth wire	- - - - -	43.395

The equatorial intervals being obtained by multiplying the time observed between any two wires, by the sine of the star's polar distance.

THE MURAL CIRCLE.

Plate VIII.

Before leaving the United States, it was deemed advisable that I should consult the Astronomer Royal at Greenwich, respecting the best plan for a mural circle, his acquaintance and experience with this peculiarly English instrument rendering his opinion of the highest importance. This was accordingly accomplished after an examination of the Greenwich circles; and Mr. William Simms, (surviving partner of *Troughton,*) having been selected to make the instrument, was requested to wait on Mr. Airy, and comply with any directions he might give.

Information I was enabled to obtain from Mr. Richardson, (the assistant having the circles principally in charge,) combined with a subsequent conversation with the Radcliffe astronomer, induced me greatly to prefer the construction of the Oxford circle; this latter instrument being not unlike the *rota meridiana* erected by Römer in 1704, and its advantages over Troughton's circles appearing to me to consist in—

1st. Stability in the meridian, by support at two points in the same plane, but opposite sides of the circle, as is the transit telescope.

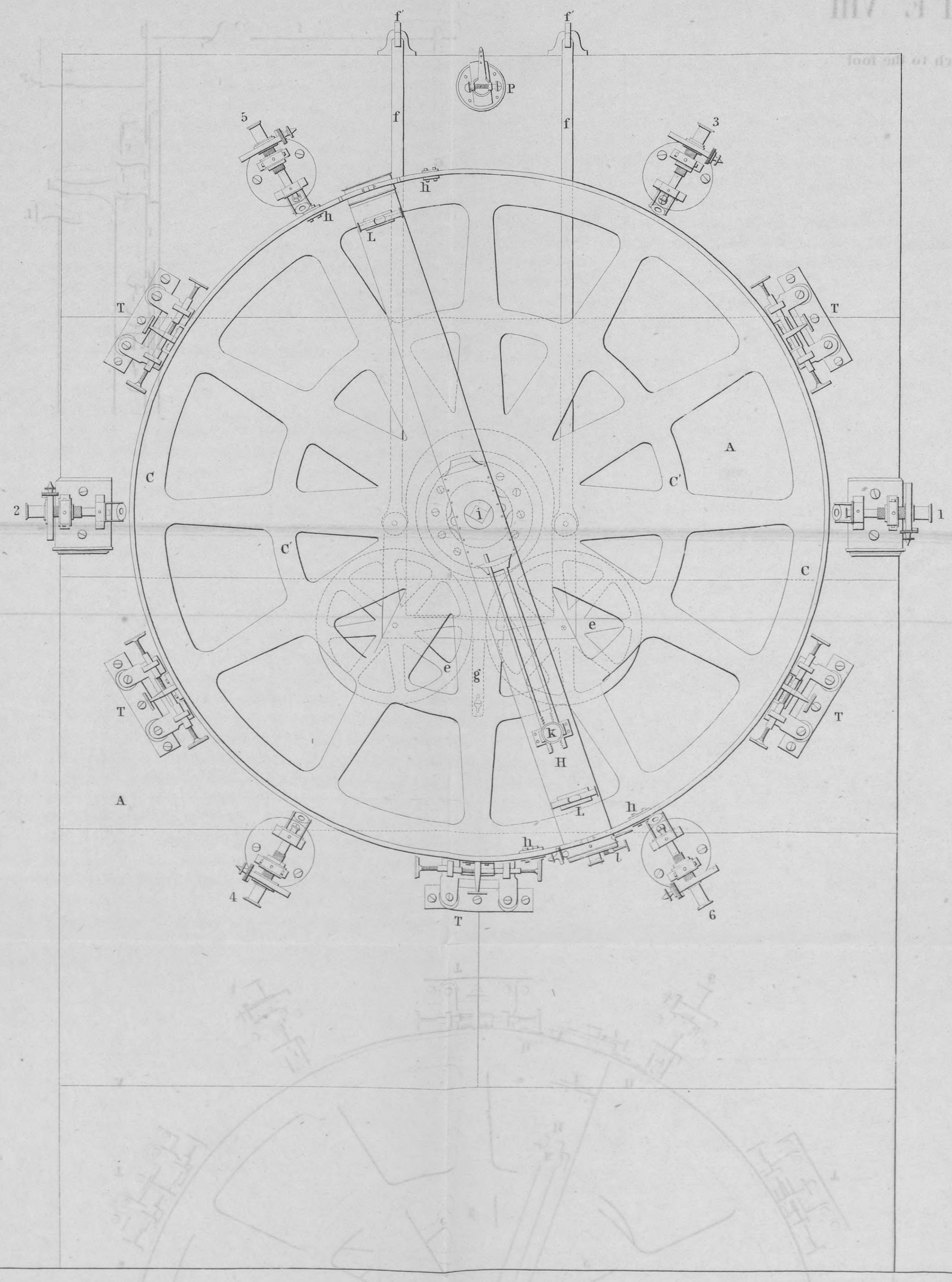
2d. Protection of the graduation from injury, by dividing on the inner face.

3d. Facility of reading, by having all direct eye pieces to the micrometers.

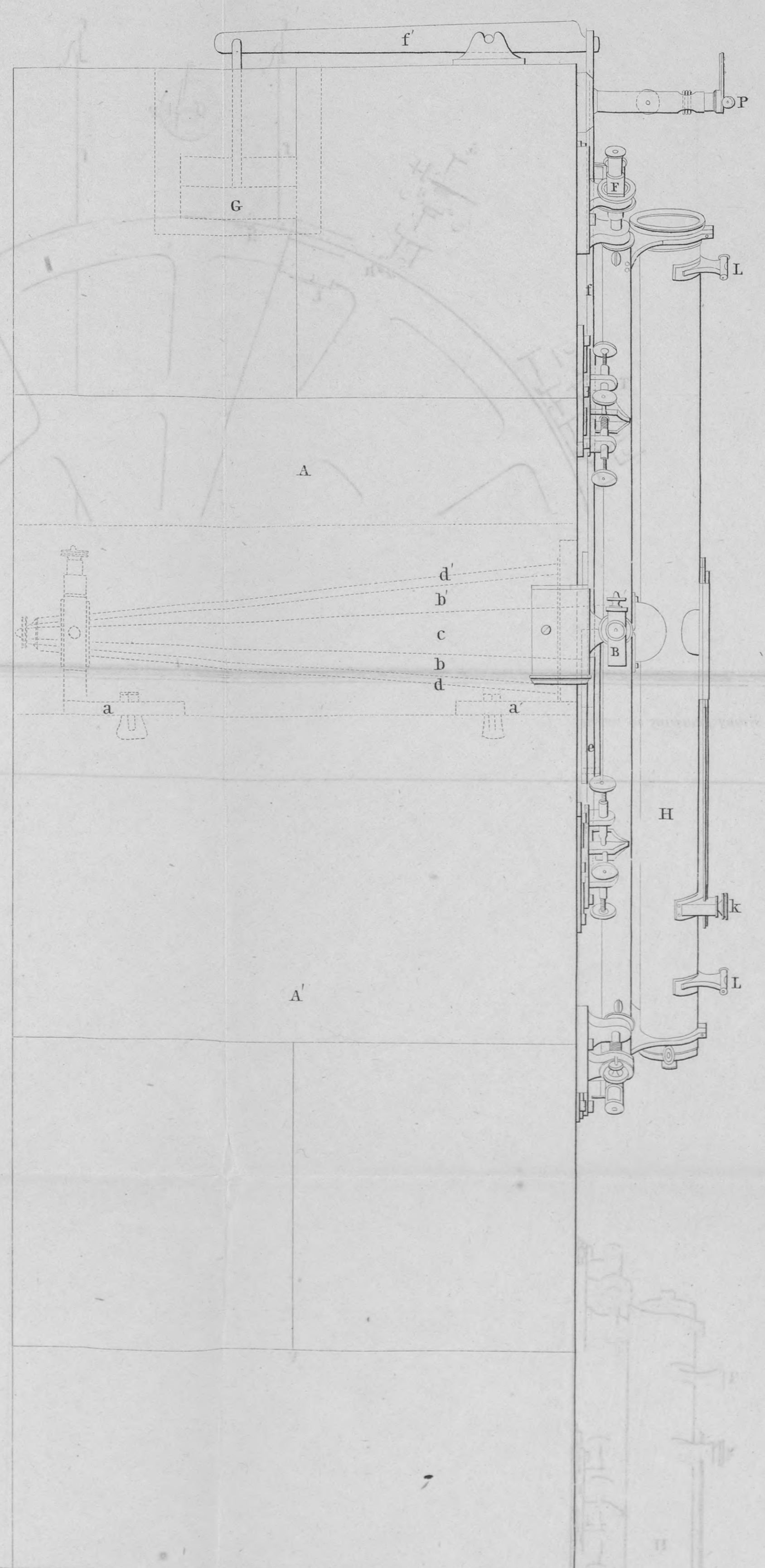
PLATE VIII

Scale one inch to the foot

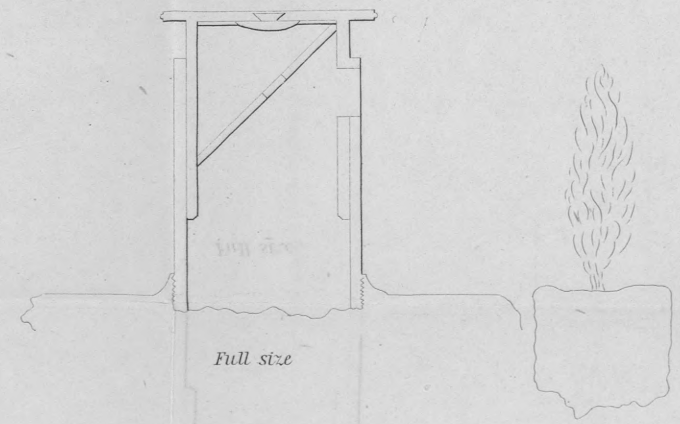
MURAL CIRCLE *Front View*



MURAL CIRCLE *Side View*



Collimating Eye Piece



Full size

Drawn by Strickland Kneass

4th. Omission of the clumsy stage necessary for reading the upper micrometers.

Apparently, time would be saved by the simultaneous employment of two persons at the mural circle, to wit: an observer, and a reader of the micrometer microscopes. Their careful reading necessarily occupies much time, and any modification tending to facilitate it is of consequence. If the observer be obliged to leave the telescope for the micrometers, he encounters different light from that to which his eye had been accustomed in its field, and a straining of the sight ensues, as well as agitation of the nervous system from mounting the stage, unfitting him for immediate renewal of observation. It was to be presumed, however, that these were not real advantages, or that Troughton's construction possessed others which were superior, and, after mentioning them, I did not presume to interfere farther.

A circle rather more than five feet in diameter was cast for Mr. Simms, by Messrs. Maudesley & Field, before I left London; and its rough exterior being turned off in a lathe, to permit an examination for fractures, the casting gave complete satisfaction. The instrument was packed in four cases, and reached New York in June last. Fearing that it might experience injury, as that sent originally to the Cape of Good Hope is supposed to have done, I visited New York on its arrival, and personally superintended the removal from the hold of the ship; its transportation to and re-stowage on board the Washington packet, and exercised the same supervision on its arrival here.

The pier A A', on which the circle is mounted, is composed of nine blocks of granite, dressed smooth, as represented in the plate, and resting on two broad slabs of the same stone, which project one foot in each direction beyond the base; its face being tolerably good planes, and joints close. The block A' is of the same length and breadth as the pier, and the circle is erected on its west side, a hole being left for the axis quite through the pier. Strong plates of brass *a a'* are secured with plugs cemented in cavities cut into the stone, as with the preceding instruments, and two screws to each; the edge of the plate *a'* projecting slightly beyond the face of the pier. Cast in the same piece with *a*, and at right angles to it, is a stout circular frame, with four adjusting screws, for holding one end of the axis. These screws act opposite to each other, and against springs, that they may be kept firmly home; two being for the level, and two for the azimuthal adjustment of the instrument. The inner diameter of the circular frame is about one inch greater than the small end of the axis which it holds, and consequently there is that range in the adjustments. Two holes in the plate *a* receive steel pins attached to the conical centre-piece *d d'*, intended to prevent lateral or azimuthal motion of the west end of the axis. The centre-piece is a hollow conic-frustum of brass, whose extremities terminate in collars of steel, accurately turned out for the reception of the axis. This latter, *b b'* is also a hollow cone, but of steel, the cavity containing a second axis of steel, *c*, (not accurately drawn,) to which the telescope is secured by capstan-head screws, the smaller end being held by a milled head screw, as shown in the side view. Upon the end of the axis next the circle is a grooved wheel, into which the friction rollers *e e* are pressed by the levers *f f f'*, and counterpoises G. The friction rollers are attached to a rectangular iron frame, with a tail piece *g* by which it is screwed to the pier; a vertical motion being allowed by a long slit cut in it. Iron rods, *f f*, with slits in their upper ends, hook into the arms of the frame, and levers *f'* of the same metal are connected with these by similar means. The counterpoises G are in sections suspended within an aperture left for them on top of the pier.

The circle C C is of brass, and connected with the central portion by twelve spokes, or radii, strenthened on their backs by edge bars, and united midway by a second concentric circle, *c' c'*. The whole is one cast, and, except the rim, or tire, has been painted. It is divided into spaces of five minutes each upon a band of gold inlaid on the rim, or perpendicular to the plane of the circle, and numbered to each whole degree on one of platina, close beside it. The connexion with the axis is by eighteen strong steel screws, twelve of which pass through the grooved wheel, and the remaining six into the central part. These screws were all inserted according to their numbers, and gradually tightened up to their places, to prevent straining.

The telescope H is a cylinder of brass secured to the circle, at its centre, by capstan-head screws which pass into a flange of the small axis *c*, and at its extremities by collars and similar screws, *h*, that clamp it to the rim. The clear aperture of its object glass is four inches, and focal length five feet. At its focus are seven vertical and one horizontal stationary wires, and a micrometer wire, movable in altitude, whose silvered head is divided into 100 parts. The illumination is through the rectangular aperture *i*, which may be opened to the size of the circle surrounding it, or otherwise regulated to moderate the light, by racks and pinions worked by the button *k*; and the eye piece, fitted into a dovetailed slide, is moved perpendicular to each of the wires by a smaller rack and pinion *l*.

Attached to the main tube are small microscopes, L, for the adjustment in level. These are four inches long, half an inch in diameter, and cut out at the centre to permit the plumb line to hang in when the circle telescope is vertical. Their object glasses are ground on one side, to soften the light. On a second piece of glass, at their foci, are small discs of brass, placed excentrically, that have minute holes at their centres. These are fitted into the same tubes as the object glasses, and the whole slides into an outer tube, and may be turned round in it, for the adjustment of the collimation lines to the same vertical plane. The plumb line is of fine silver wire, suspended from a small hook at the upper part of the support P, which is cemented to the pier; and the weight, is a perforated cylindrical box, filled with shot, and hanging in a vessel of water, to check its oscillations. The support P has a rack and pinion motion to carry the plumb line out beyond the microscopes, in order that the telescope may be turned round without breaking it; a fine screw motion, in the same direction, by which the aperture in the *ghost* may be accurately bisected; and a horizontal screw, between the threads of which the plumb line hangs, for giving it a slow motion and adjusting it to distinct focus.

Placed at equal distances round the circle, are six micrometer miscroscopes, with achromatic object glasses and an acute cross of wires at their foci, for reading measured angles less than five minutes. Four of them (viz: 3, 5, 4, and 6,) are upon stout circular brass plates, attached to the pier by four plugs and screws to each; and numbers 1 and 2 have rectangular plates resting upon brackets let into the granite, and three screws to each. They are engraved by the maker A, C, E, B, D, F, corresponding to 1 3, 5, 2, 4, 6, of the drawing, and are secured to the plates by strong pieces of brass projecting from their faces, with circular apertures through which they pass. To render them firm, screw collars work on each side of the projecting piece next the eye ends, and screws passing through the pieces near the object ends hold them tight. The collars serve also to adjust them for distinct vision of the divided limb of the circle. They have been accurately corrected as to focal length by Mr. SIMMS, "so that five revolutions of the micrometer may measure five minutes upon the circle. This may be subject to some variations by changes of temperature, but the runs must be taken from time to time, and due allowance made." The heads being divided into sixty equal parts, each division represents *one second of arc*. There are three screws to each of the pieces next the eye ends of the micrometers, by which slight vertical or lateral motions may be given to them. Numbers 4 and 6 have been furnished with prismatic eye pieces, and it would add much to the convenience of reading them, if 3 and 5 were similarly constructed.

Five clamps, with tangent screws, T, are arranged as in the drawing, being secured to plugs cemented in the pier. They require no description, except what Mr. Simms says of them: "One of the clamps is therefore always in reach of the observer. The tangent-screw heads have been notched, at the suggestion of the Astronomor Royal, who some time since had those at Greenwich so done. It is desirable that all observations be finished by turning the tangent screws in the same direction; and the use of the notches is to guide the observer in this particular. When the screw is so turned that its action *opposes* the spiral spring, (and it should be always so turned,) then the perpendicular side of the notch clings to the thumb or finger; but if the screw be turned the other way, the fingers slip freely and unresisted over the slopes; hence the observer can have no hesitation as to the direction in which he is turning the screw."

The instrument was accompanied by four extra eye pieces, of different magnifying powers,* which have been determined and engraved upon them by the maker; a prism; colored shades for observations of the sun; and tools for putting up and adjusting it.

For convenience of reading the two lower micrometers, a step was made in the floor, below its level; and, for the two upper ones, a double flight of steps, supporting between them, and next the circle, a platform of sufficient height. To prevent contact with the circle, there is an iron railing round the platform, and, to make it steady, the newel of the handrail passes through the floor, and is screwed down beneath.

A lamp for illuminating the telescope and miscroscopes will occupy a stand at the distance of five feet from the circle, and a metallic frame, covering it, will permit the passage of eight pencils of light through lenses so adjusted that the incident cones of rays on reaching the circle will have only the diameter of the circular aperture in its telescope, or the silvered microscope reflectors. The eighth pencil will illuminate the dial of the clock, and the heat and smoke be conveyed through the roof by a pipe attached to the lamp frame. This last will consequently be permanent, and the lamp itself movable, that it may be filled or cleaned. The apparatus is making by Messrs. T. W. & R. SMITH, Alexandria, D. C., a solar lamp having being selected for the purpose.

The cost of the MURAL CIRCLE, when packed, was £730—about $3,550.

* The higher powers cannot easily be used, the construction of the telescope preventing the eye of the observer being brought sufficiently near.

ADJUSTMENTS OF THE MURAL CIRCLE.

August 12, 1844.

Suspended the plumb-line apparatus, placing the weight in a vessel of water, to check its oscillations, and carefully levelled the axis, adjusting alternately by the screw at its eastern extremity, and the *ghost* of the small microscopes, turning the object glasses with the excentric disc of brass in their cells for the purpose.

The line of collimation of the circle telescope was next examined, by the collimating eye piece and basin of mercury, and found to have been correctly adjusted by the maker, without subsequent derangement.

Removed the plumb line, turned the circle till the division 360° was under the pointer attached to microscope A, and adjusted the micrometers accurately to 360°, 60°, 120°, 180°, 240°, 300°, the order being from southern horizontal by the lower, to the northern horizontal, A, F, D, B, E, C, which is also the order of the divisions of the circle.

Transits, simultaneously observed with the transit instrument, showed that the plane of the circle coincided very nearly with the meridian.

In the following, as in all subsequent attempts to examine the divisions of the instrument, the circle was turned by hand to the approximate position, and the concluding motion given by the tangent screw, the final direction of the screw being in every case against the action of the spring. The thermometers were placed quite close to the circle.

Tangent screw below A used.

	A	B.	C.	D.	E.	F.	Upper.	Lower.	Remarks.
°	"	"	"	"	"	"	°	°	
0	0.0	0.0	0.0	0.0	0.0	0.0	73.5	72.5	
5	0.0	+ 0.5	0.0	− 2.5	− 2.5	+ 0.3			
10	0.0	+ 0.5	+ 0.8	− 0.3	+ 1.0	− 0.6			
15	0.0	+ 0.5	− 1.8	− 0.5	− 1.5	− 0.6			
20	0.0	+ 0.8	− 0.7	+ 0.6	− 1.2	+ 1.0			
25	0.0	+ 0.8	− 0.3	+ 1.0	− 3.8	− 1.0			
30	0.0	0.0	0.0	− 0.4	− 1.2	+ 0.2	74.5	73.5	
35	0.0	+ 0.6	− 1.2	+ 0.8	− 3.2	+ 0.3			
40	0.0	0.0	− 1.2	+ 2.3	− 0.3	+ 3.0			
45	0.0	− 1.3	− 2.0	+ 2.0	− 2.4	+ 1.8			
50	0.0	− 0.5	− 2.2	+ 2.7	− 2.5	+ 3.5			
55	0.0	+ 0.2	− 2.7	+ 6.9	− 4.5	+ 5.1	......	......	Re-examined.
60	0.0	0.0	− 2.9	+ 5.3	− 6.8	+ 6.6	74.7	74.3	
65	0.0	− 2.5	− 5.4	+ 5.3	− 8.6	+ 3.0	......	......	Re-examined.
70	0.0	+ 0.3	− 2.5	+ 6.0	− 4.0	+ 6.8			
75	0.0	0.0	− 2.4	+ 8.4	− 5.2	+ 7.3			
80	0.0	0.0	− 6.1	+ 8.3	− 9.5	+ 8.3			
85	0.0	0.0	− 5.0	+ 11.6	− 8.9	+ 11.2			
90	0.0	0.0	− 8.1	+ 11.3	− 11.5	+ 10.0	75.5	75.0	
95	0.0	+ 0.5	− 8.0	+ 13.0	− 10.0	+ 12.5			
100	0.0	0.0	− 11.0	+ 12.2	− 14.2	+ 13.5			
105	0.0	+ 0.7	− 7.8	+ 13.6	− 12.0	+ 14.7			
110	0.0	− 0.6	− 12.2	+ 11.3	− 15.0	+ 11.8			
115	0.0	0.0	− 11.0	+ 14.0	− 13.0	+ 17.0			
120	0.0	− 1.9	− 13.0	+ 13.9	− 15.0	+ 14.0	76.0	75.2	

The action of the clamp and tangent screw in drawing the circle to the south was so evident, that the examination was discontinued, under belief that the plate supporting the western end of the axis was loose. This was not the case. The clamps were therefore taken off and oiled under the slides, and Bristol boards put under their supports, that they might more correctly accommodate themselves to the circle, in securing them to the pier again.

Upon their being replaced, no motion of the circle appeared to be caused by clamping or unclamping it with any one of the five; but if the tangent screw was turned after clamping, and the clamp then loosed, there was an evident jump of the circle downward in every case. As this, however, might have been a motion about its axis, and not one of translation, an attempt was again unsuccessfully made to examine the divisions. The amount of change was greatly reduced, being in 120° only 3″ instead of 14″.

The clamps were again taken off, and springs to the sliding portions eased; the weight of the counterpoise reduced; friction rollers examined, and micrometers once more adjusted to their 0°, 60°, 120°, 180°, 240°, 300°. The bed plate *a'* under the axis was screwed as tight as was consistent with safety to the threads, as was also *a*, and the entire weight of the circle allowed to bear upon the axis, that the holding-pins might more securely sink into their sockets. The counterpoise being restored, my last examination was made on the 7th October, using the clamp under A., as before.

	A.	B.	C.	D.	E.	F.	Upper.	Lower.
°	″	″	″	″	″	″	°	°
0	0.0	0.0	— 0.5	+ 1.0	+ 0.5	— 0.3	53.5	53.5
10	+ 0.5	+ 1.5	+ 1.0	+ 2.8	+ 1.2	0.0		
20	+ 0.8	+ 0.9	+ 0.3	+ 3.3	+ 1.8	0.0		
30	— 0.6	+ 0.0	— 0.1	+ 3.9	+ 0.1	+ 1.0	53.8	53.7
40	— 1.8	— 1.9	— 0.5	+ 3.0	— 1.4	+ 0.2		
50	— 1.8	— 1.4	+ 0.8	+ 2 3	— 0.2	0.0		
60	+ 1.8	+ 2.5	+ 6.2	+ 6.6	+ 3.5	+ 4.2	53.8	53.7
70	+ 0.2	+ 2.3	+ 5.0	+ 7.0	+ 4.0	+ 4.0		
80	+ 0.7	+ 1.1	+ 3.5	+ 5.8	+ 2.8	+ 2.6		
90	+ 0.8	+ 1.3	+ 1.8	+ 5.7	+ 1.1	+ 4.0	53.7	53.7
100	— 0.8	+ 0.6	+ 0.2	+ 6.8	+ 0.5	+ 5.8		
110	— 0.7	— 0.2	— 0.9	+ 5.0	+ 0.8	+ 3.1		
120	— 1.3	— 1.8	— 3.5	+ 4.5	— 1.2	+ 4.8	54.3	54.3
130	+ 1.1	+ 2.3	— 1.5	+ 7.7	+ 1.8	+ 6.5		
140	— 0.1	+ 1.8	— 1.7	+ 7.0	— 2.3	+ 3.0		
150	— 0.3	— 0.8	— 1.7	+ 5.0	0.0	+ 3.3	54.2	54.5
160	— 1.0	— 1.9	— 4.2	+ 3.5	+ 5.0	+ 1.5		
170	— 1.7	— 3 3	— 5.8	+ 2.5	— 6.5	0.0		
180	— 1.8	— 2.0	— 2.6	+ 1.2	— 4.5	+ 0.5	54.2	54.3
190	— 1.8	— 1.6	— 3.3	+ 5.3	— 6.1	+ 1.4		
200	+ 3.0	+ 2.0	+ 0.2	+ 9.0	— 1.5	+ 6.1		
210	+ 1.7	+ 1.2	+ 0.1	+ 8.5	— 1.8	+ 5.8	54.1	54.2
220	+ 2.0	— 1.1	+ 1.8	+ 6.7	— 0.8	+ 3.2		
230	+ 1.8	— 0.8	+ 0.8	+ 6.9	— 0.8	+ 4.0		
240	+ 0.5	+ 0.3	+ 1.7	+ 8.0	+ 1.6	+ 3.5	54.0	54.1
250	+ 0.6	— 0.4	+ 0.7	+ 8.6	— 0.5	+ 4.5		
260	+ 1.8	+ 1.0	+ 0.7	+ 9.6	+ 1.0	+ 6.8		
270	+ 0.4	+ 2.0	+ 0.2	+ 9.2	+ 2.0	+ 7.0	54.2	54.1
280	+ 0.5	+ 2.0	+ 1.0	+ 9.0	+ 1.5	+ 6.4		
290	+ 0.5	+ 2.0	+ 0.4	+ 9.0	+ 1.1	+ 7.1		
300	+ 0.0	+ 0.7	— 0.9	+ 5.8	— 0.4	+ 5.7	54.1	54.2
310	+ 1.0	+ 1.1	— 0.4	+ 6.4	+ 1.6	+ 6.8		
320	+ 1.0	+ 1.0	— 0.0	+ 6.0	+ 0.5	+ 5.2		
330	+ 1.5	+ 2.2	+ 0.4	+ 8.5	+ 1.4	+ 6.0	54.3	54.5
340	+ 2.4	+ 2.2	+ 1.5	+ 7.8	+ 2.1	+ 3.8		
350	+ 3.8	+ 3.4	+ 0.5	+ 10.8	+ 2.3	+ 6.3		
360	+ 0.2	+ 0.3	— 3.1	+ 7.3	— 2.6	+ 1.6	54.2	54.3

Revolved the circle 360° in the order of the divisions, and renewed the examination, using the same clamp.

	A.	B.	C.	D.	E.	F.	Upper.	Lower.
°	"	"	"	"	"	"	°	°
360	+ 1.0	+ 0.8	− 2.6	+ 6.7	− 2.3	+ 1.7	54.2	54.3
10	+ 0 5	+ 2.1	− 1.5	+ 9.0	− 1.0	+ 1.9		
20	+ 0.0	+ 0.5	− 1.2	+ 7.6	− 1.0	+ 0.7		
30	+ 0.2	0.0	− 3.0	+ 8.5	− 2.8	+ 2.8	54.1	54.3
40	+ 3.2	+ 3.5	+ 1.6	+ 13.2	+ 1.0	+ 8.3		
50	+ 1.1	+ 0.8	− 1.0	+ 11.0	− 1.5	+ 5.5		
60	+ 2.8	+ 2.0	+ 0.3	+ 12.2	− 1.8	+ 7.5	54.0	54.3
70	+ 2.9	+ 3.4	+ 1.0	+ 15.0	+ 0.1	+ 10.5		
80	+ 2.9	+ 4.0	+ 1.2	+ 14 9	+ 1.0	+ 10.5		
90	+ 2.0	+ 3.5	+ 0.7	+ 12.8	+ 1.2	+ 8.8	53.8	54.0
100	+ 2.0	+ 2.3	− 2.2	+ 12.7	− 0.6	+ 9 3		
110	+ 2.0	+ 2.0	− 2.5	+ 13.2	− 0.8	+ 9.8		
120	+ 2.0	+ 1.7	− 3.0	+ 11.3	− 0.1	+ 10.0	53.7	53.8
130	+ 2.4	+ 2.8	− 1.6	+ 11.5	+ 1.8	+ 11.5		
140	+ 1.2	+ 3.0	− 3.1	+ 11.3	+ 0.5	+ 8.3		
150	+ 1.0	+ 2.5	− 3 5	+ 10.7	− 1.0	+ 8.0	53.7	53.8
160	+ 1.0	+ 1.5	− 4.1	+ 9.8	− 4.5	+ 7.0		
170	+ 1.0	+ 1.0	− 3.1	+ 8.0	− 2.6	+ 5.3		
180	+ 1.0	+ 1.2	− 3.6	+ 8.6	− 3.7	+ 5.2	53.7	53.8
190	+ 1 0	+ 1.0	− 3.5	+ 9.7	− 4.9	+ 6.0		
200	+ 1.0	+ 1.0	− 3.5	+ 9.5	− 5.1	+ 6.6		
210	+ 1.0	− 0.8	− 2.4	+ 8.5	− 3.3	+ 5.3	5. 7	53.8
220	+ 0.8	− 2.0	− 3.0	+ 8.9	− 5.4	+ 5.3		
230	0.0	− 1.3	− 3.2	+ 8.4	− 4.0	+ 5.0		
240	0.0	0.0	− 1.1	+ 10.0	− 1.5	+ 5.0	53.7	53.8
250	+ 0.5	− 1.0	− 0.9	+ 10.0	− 1.1	+ 5.7		
260	0.0	+ 0.3	− 4.4	+ 11.9	− 2.5	+ 7.7		
270	0.0	+ 0.5	− 5.3	+ 11.0	− 2.8	+ 6.9	53.7	53.9
280	0.0	+ 1.0	− 3.2	+ 10.5	− 1.5	+ 8.0		
290	0.0	0.0	− 3.9	+ 10.5	− 3.0	+ 8.0		
300	0.0	+ 1.3	− 3.5	+ 10.0	− 2.9	+ 8.0	53.9	54.0
310	0.0	0.0	− 2.9	+ 6.5	− 0.2	+ 6.5		
320	0.0	− 0.2	− 4.5	+ 7.0	− 4.1	+ 5.5		
330	0.0	+ 0.5	− 3.2	+ 8.8	− 2.8	+ 6.0	54.1	54.1
340	0.0	+ 0.8	− 2.5	+ 7.0	− 1.7	+ 4.0		
350	0.0	+ 0.5	− 5.0	+ 8.7	− 3.6	+ 5.0		
360	+ 0.3	+ 0.5	− 6.0	+ 9.3	− 5.4	+ 4.3	54.2	54.2

The instability of the axis has not been overcome, and it will probably be necessary to dismount the circle, before it can be remedied.

Lieutenant Maury, having taken charge of the instruments on the 8th of October, has doubtless adjusted it for observation.

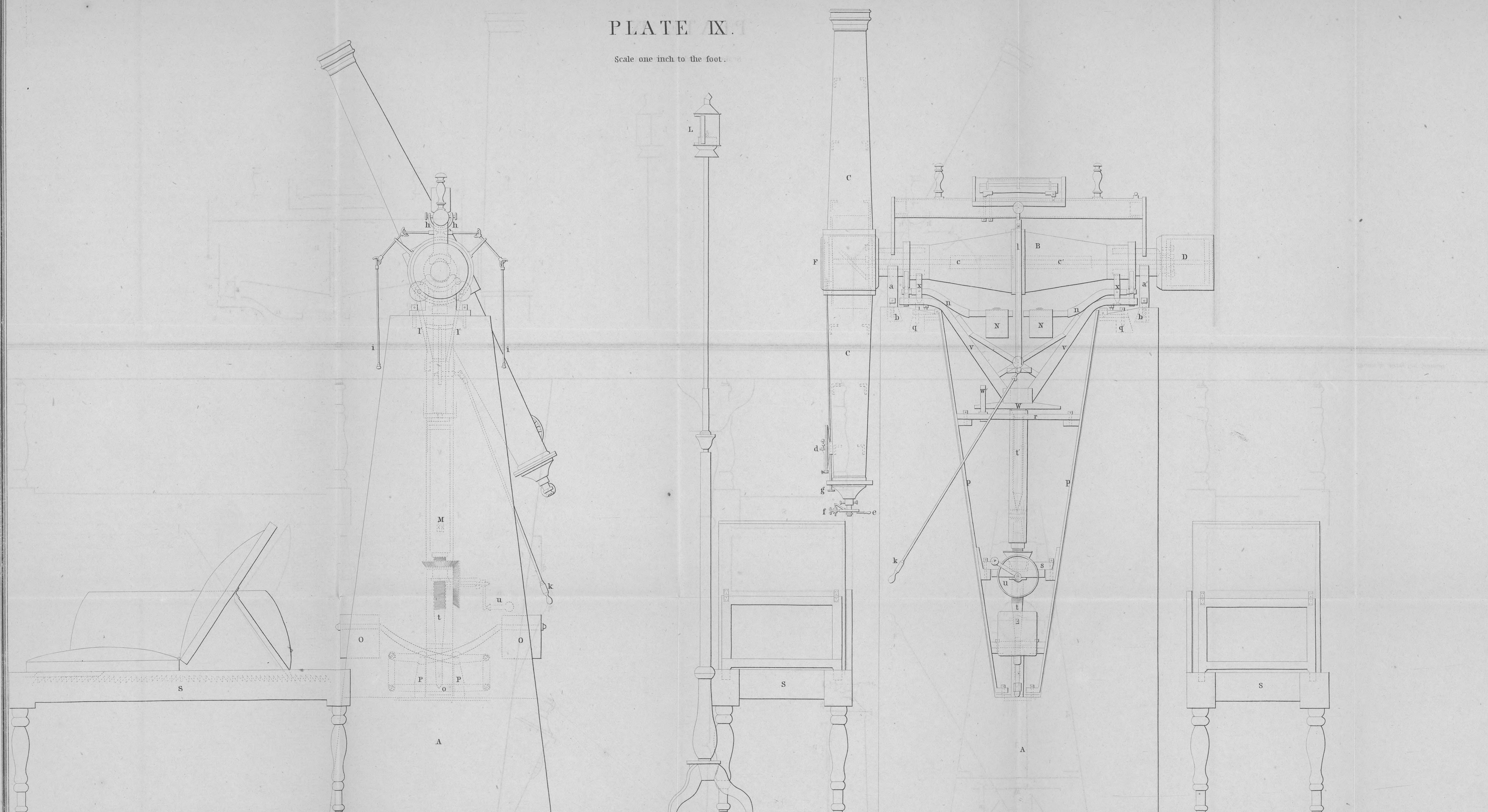
TRANSIT IN THE PRIME VERTICAL.

Plate IX.

In a report to the Imperial Academy of Sciences at St. Petersburg, Professor Struve says: "From the moment that I made use of a transit instrument in the prime vertical in 1826, I was convinced that the observations would be susceptible of greater precision, if it were possible to give to the instrument itself a form suitable to the object contemplated; and that, with such modification, it must entirely supersede the ZENITH SECTOR in the ultimate researches of *aberration, nutation*, and the *annual par-*

PLATE IX.

Scale one inch to the foot.



Drawn by Alexey Von Schmidt

allax. The changes essential to execute were: 1st. To alter the position of the tube, placing it at the extremity of the axis of rotation, that the level might have a constant place upon the axis; whence would result a more exact knowledge of its inclination, an absolute requisite, since the inclination acts directly on the observed zenith distance: and, 2d. To unite with the instrument a suitable apparatus for the most speedy reversal possible; an operation which would serve to eliminate, more immediately, all hypothesis respecting the invariability of the connexion of its different parts, and especially, of the angle between the optical axis and that of rotation."*

In equipping the Pulkova observatory, an opportunity was offered to attempt such an instrument, and models were presented by Repsold, *frères*, of Hamburg, and Messrs. Ertel & Son, of Munich. That of the former was adopted, from the great perfection of its reversing apparatus, and an instrument constructed about seven and a half feet focal length. It had then been in use more than two years—Professor Struve expressing the greatest satisfaction with its performance, and the results of his observations for the co-efficient of aberration presenting a degree of accordance hitherto unknown—strong presumptive evidence of the skill of the observer as well as the accuracy of his instrument.

It appears that the reversing apparatus leaves nothing to be desired, the operation of reversal being perfected in *sixteen seconds of time*; "and if the astronomer has commenced his observation of transits to the north of the pier, he may continue it with the instrument reversed and tube to the south, after *one minute and twenty seconds*—this time being sufficient for him to rise from the observing chair, loose the clamp screw, remove the key from the slow-motion screw, reverse the instrument, direct it again to the star by the level attached to the finder, clamp it, replace the slow motion key, and re-seat himself for observation." This form was therefore no longer an experiment, the most brilliant success having resulted from its use; but if there had been any doubt of the importance of such an instrument in an observatory, the opinions of Professors Schumacher, Encke, and Rümker, would have fully removed them; the zenith sector, if not absolutely a failure, not having realized the expectations formed of it.

The reputation of Messrs. Repsold made it desirable that they should be employed in constructing one of the instruments for the Washington observatory; and as this particular one was of their own invention, it appeared the most appropriate; I therefore visited Hamburg, thinking to give them the order. Their engagement to complete a large heliometer for Oxford within a stipulated time, and additional duties as superintendents of the fire department, growing out of the great conflagration which had recently occurred, compelled them to decline undertaking it, unless they could be allowed four years for its completion. This being impossible, its execution was intrusted to Messrs. Pistor & Martins, at Berlin. It was punctually completed, packed in four cases, and shipped to the United States in October, 1843, but, from ice in the river, did not reach Washington till late in February, 1844. On opening the cases, the pivots, though wrapped with fine tissue paper, and enveloped in woollen cloth coated with tallow, were found covered with minute specks of rust. These were removed, as carefully as possible, with a soft linen handkerchief, and the pivots have been cleaned with like material two or three times each subsequent week.

* **Bulletin de l'Academie des Sciences de St. Petersburg, tom. X.**

Plate IX represents two views of the instrument; the first, from the north, projected on the plane of the prime vertical, with the telescope to the south of the pier; and the second, from the west, projected on the plane of the meridian, with the telescope to the north. The pier A is a single block of granite, of which about five feet is below the floor line, and is cut to form two columns, separated by a cavity intended for the reversing apparatus. To these columns are secured the Y's *a a*, of brass, by strong steel screws and plugs *b b* cemented in; *a* admits of a slight change in altitude, or level of the axis, and *a'* a correction for the azimuthal deviation. The axis B is 42 inches long. Its body is of cast brass, conical, and hollow, and terminates in pivots of fine steel 3½ inches in diameter.

To one of them is attached the tube C, and to the other a cylindrical counterpoise D. Each pivot is perforated to permit the passage of steel levers, *c c'* whose fulcra have gimbal suspensions, resting by their exterior rings on the hollow of the pivot, and which serves to transmit the weight of the telescope and its counterpoise to the section of the Y's immediately in contact with them. To accomplish this, one extremity of the lever is firmly screwed to the outer side of the cubical box forming the centre of the tube, and the other is loaded with a cylindrical counterweight of lead. That part of the lever which passes across the telescope, and would intercept rays of light coming from the object glass, is in the form of a ring. A second similar counterpoise, with the exception of the ring for the passage of light, is on the opposite side, to produce a like effect on the counterpoise D.

The telescope is formed of two slightly conical tubes, fitting to a shoulder in the cubical box, and screwed firmly to it. Its object glass has a clear aperture of 5 inches, with a focal length of 78 inches. The other portion of the tube has a finder circle *d* 7½ inches in diameter, divided from 10' to 10', and reading by two verniers to 10'', a small level being attached to the alhidade. The eye tube slides within the main tube, and is furnished with clamps, serving to place the wires vertical, as well as to retain them at celestial focus. The system, or reticle, is composed of two horizontal and fifteen vertical stationary wires, and one movable vertical wire, with micrometer screw and silvered head, *f*, divided into one hundred parts, and the eye piece is moved perpendicular to each of them by a small lever, *e*. A circular aperture in the cubical box at F, glazed with plate glass, gives ingress to rays of light from the lamp L, (too elevated in the drawing,) which are reflected by a diagonal mirror to the reticle at the focus. This, with a second similar lamp on the opposite side, will furnish sufficient light for all purposes. The quantity admitted in the telescope is regulated by a rod of steel, terminating in the button, *g*, whose motion enlarges or diminishes at will the aperture at F.

The axis is surrounded at its centre by a metallic ring, *l*, open at top, and furnished there with a screw, worked from either side by the handles, *i i*, which clamp it firmly. The lower part of the ring has joined to it a triangular tail piece, *l' l'*, embracing below, a micrometer screw, worked by the handle *k* through a fixed part of the reversing apparatus, and giving slow vertical motion to the instrument when it is clamped. In this part of its construction, it is much more simple than the Pulkova instrument.

The level is upon the axis. Its glass tube rests in a semi-cylinder of brass, fixed upon a strong tube fitted with two wood handles, and which touches the pivots by feet, whose planes are cut at right angles. To augment the accuracy of its indications, it is furnished with a small transverse level, and the large tube is covered with a plate glass box. The former insures readings in the same vertical plane, and the latter secures it against the action of radiating heat when the observer approaches; and to this end, also, the whole of the brass work outside the glass case is covered with dark woollen cloth. These precautions are absolutely indispensable, when it is desired to know the inclination of the axis to small fractions of a second. In order that the bubble may be uniform in length, a disc of glass has been fitted into one end of the tube about an inch from its end, so as to make a separate chamber, that is partially filled with air. A small aperture has been left in the bottom of the disc, for the passage of air or ether from the longer to the shorter side, or vice versa; hence, when the liquid expands, and shortens the bubble, by turning the level, with the reserve chamber downwards, ether runs into the chamber, and air passes upwards to take its place; or, if the bubble is inconveniently long, the operation is reversed. This also preserves the instrument during the heat of our summer, when, if not in a cool place, it might be destroyed. The level is kept securely on the axis by quadrantal prolongations of the clamp ring, forming, together, a semicircle, *h*, which clasps it.

The reversing apparatus is supported by the iron frame, *p*, which is half an inch thick and four inches wide. It is open above, and placed within the cavity of the pier. Plugs of brass, *q q*, cemented into the pier, are prolonged into shoulders, through which pass strong steel screws turning horizontally, that support the weight of the apparatus on their four points, and serve also for its rectification to the meridian and a vertical plane. Two other screws secure it to the plugs, but it is no where in contact with the pier, in order that it may dilate according to temperature. Iron cross pieces *r* and *s* unite the opposite sides of the frame with each other. A vertical steel axis *t* passes through these cross pieces, the portion passing through *s* being formed into a long screw, to which motion is given by the bevelled wheels and crank *u*. To the upper part of this axis, and moving with it, is fixed a hollow brass cylinder, working tight in the upper cross piece. A second steel axis, *t'*, resting on an adjustible plate of the same metal, M, turns within the cylinder, and its upper portion formed into strong arms, *v v*, has circular cushions, *x x*, which fit the axis, B, when the vertical axis *t* is raised by means of the crank. Curved levers, *n n*, whose points of support are below *x x*, are loaded with cylindrical counterpoises, N N, so as to act with a constant upward pressure upon the axis, B, there being a cross arm at their extremities, fitted with friction rollers, which travel in a groove of the axis. Above the brass cylinder, and attached to the arms, *v v*, is a cross piece, *w*, with a correcting screw at one end, that strikes against the upright, *w'*, and permits the reversing carriage to turn about its vertical axis only 180°.

To diminish the power necessary to be applied to the crank in raising the instrument from the Y's, the artists have contrived an extremely ingenious system of levers.

The axis *t* terminates below in a truncated cone, resting in a conical hollow at *o*, on which acts masses of lead, O O, applied to two levers sustained by vertical pieces, P P, supported on the interior base of the pier. When the crank is turned to raise the instrument by the vertical axis, the counterpoises, O O, descend, until they touch the interior horizontal plane of the stone; and on the descent of the axis, to replace the instrument in its

Y's, they remount. The effective force is thus reduced to a few pounds, although the weight to be raised is not less than 750 pounds. When the axis is in its Y's, the arms of the carriage rest on screw heads, as shown in the drawing, and the steel plate is so adjusted at M that the pressure is relieved from the conical point of the axis t'.

The instrument was accompanied by extra eye pieces of different magnifying powers, a prism for observations near the zenith, colored shades, and all necessary tools for erecting and adjusting it.* Its mechanical execution reflects the highest credit on Messrs. PISTOR & MARTINS, the great pivots on which so much of its capability depends being *accurately cylindrical, and almost, if not quite, mathematically equal.* The object glass, too, is of very high character, the companion to γ *Leonis* being distinctly perceptible at transit over the prime vertical, when in conjunction with the sun.

There are two observing chairs, S S, moving on rollers, with side pieces next the pier, to prevent the observer leaning against it; and a flight of steps on the west side, for convenient reading of the level, &c. The clock pier is immediately to the east, as seen in the ground plan.

The cost of this instrument, including packing and transportation from Berlin to Hamburg, was 2,500 Prussian thalers—about $1,750.

ADJUSTMENTS OF THE PRIME VERTICAL TRANSIT INSTRUMENT.

AUGUST 14, 1844.

Telescope south of the pier and vertical, with the object glass downwards. Attached the collimating eye piece, placed a basin of mercury beneath, and made the wires coincide with their image seen reflected. Set the vernier of the finder circle to 0°, and moved the telescope till the horizontal wires and their images coincided; the bubble was then adjusted to the centre of the tube, and the following observations made with the level:

North end.	South end.
15.0	14.8
15.0	14.8
15.0	14.8
Level reversed.	
14.9	14.7
14.9	14.7
14.9	14.7
Sum 89.7 north.	Sum 88.5 south.
Sum 88.5 south.	
12)1.2 diff.	

div. ″
0.1 = 0.140 arc, north end high.

---

* One of the eye pieces being secured into place after the instrument was mounted, upon moving it by the small lever across the field of the telescope, a part of the wires were torn out. They were subsequently replaced by Mr. Brown, instrument maker to the depôt, and the frame of the eye piece filed off inside, to prevent future accidents.

The error of collimation in azimuth is therefore 0''.140 arc; or 0''.093 time; but, as this is less than the unavoidable errors of observation, it may be entirely disregarded in the subsequent transits of α *Lyræ.* But the full power of the instrument requires that it be used on each side of the pier at the transit over each vertical: thus, the transit of a star over the east vertical must be observed at each of the first seven wires, with the tube to the north; the instrument is then to be reversed, and transit observed *over the same seven wires,* with the tube to the south, and the same to be repeated at the west vertical, commencing the observations *with the instrument on the side of the pier last used.* If this method of observation be followed, it may be shown that the error of collimation will be—

$$\text{Sin.}\,\Gamma = \text{sin.}\,\frac{t'+t.}{2}\ \text{sin.}\,\frac{t'-t.}{2}\ \text{cos.}\,\delta\ \text{sin.}\ \text{L}.$$

In which t and t' are any two corresponding horary angles, δ the apparent declination of the star, and L the latitude of the observatory.

SEPTEMBER 25, 1844.

Tube horizontal, object glass east, and temperature 71° at 10 hours A. M. Levelled the axis, the value of one division, as given by Messrs. Pistor & Martins, being 1''.40 arc:

North end.		South end.
21.1		21.8
21.1		21.8
20.9		21.8
21.0		21.9
20.8		22.0
	Level reversed.	
21.8		20.7
21.7		20.8
21.9		20.5
21.9		20.5
21.8		20.5
Sum 214.0 north.		Sum 212.3 south.
Sum 212.3 south.		
20)1.7 diff.		
div. 0.085 = 0''.119 arc, north end elevated.		

The object being to ascertain the azimuth of the axis of rotation, and the instrument having remained to the north of the pier during the transits over the east and west verticals, it is evident that the *middle* time is not affected by the error of level.

SEPTEMBER 30, 1844.

Professor Coffin made the following observations, the rate of the sidereal chronometer being + 4''.10 daily:

α Corona Borealis.

Vertical east.	Wire.	Vertical west.
hrs. ' ''		hrs. ' ''
10 29.0	VII	53 52.0
12 10 46.0	VIII	18 53 36.0
11 01.7	IX	53 19.8
11 09.0	X	53 11.7

Mean, 15h. 32' 10''.65.

The meridian transit is forty-five feet to the west of the prime vertical instrument, and correcting the observation of *α Corona Borealis* at transit over the meridian, for the difference = 0''.06, we have 15h. 32' 14''.88 as the time by the chronometer, at which it passed the medirdian of the prime vertical instrument, the difference between which and the mean of the times is - - - - - - - 4''.23

α Lyræ.

Vertical east.	Wire.	Vertical west.
hrs. ' '		hrs. ' ''
58 35.0	I	12 58.5
59 19.5	II	12 13.5
00 05.0	III	11 28.5
00 53.5	IV	10 40.0
01 39.0	V	09 53.5
02 27.5	VI	09 06.0
03 18.0	VII	08 18.0
18 05 00.5	VIII	19 06 32.0
06 49.5	IX	04 44.5
07 46.0	X	03 48.5
08 45.0	XI	02 48.0
09 49.5	XII	01 46.0
10 52.5	XIII	00 42.0
12 00.0	XIV	59 35.0
13 10.0	XV	58 24.0

Mean 18h. 35' 46''.95.

The transit of *α Lyræ* corrected, was observed at 18h. 35' 50''.64, the difference between which and the preceding is - - - 3''.69

From these two observations the azimuthal deviation may be computed by the formula

$$\triangle = D \sin. L.$$

D being the difference as above, and L the latitude of the observatory; and substituting numerical values, we obtain from

	''
α Corona Borealis - - - - - -	2.656
α Lyræ - - - - - - -	2.317
Axis of rotation east of south meridian - - - - -	2.486

It is evident that it is not necessary to observe the transit of the star over the meridian if its right ascension, and the error of the sidereal clock be accurately known.

To determine the angular value of a revolution of the micrometer screw, the intervals of time occupied in passing from the 7th to the 8th wires was observed of the following stars, and the mean of all the observations given by

	$''$
ε *Bootis*	16.60
α *Corona Borealis*	16.12
30 *Leonis Minor*	25.75
β *Tauri*	17.00
α *Bootis*	13.35

From these the amount is obtained by the formula

$$P = \tau, \cot. A \sin. \delta.$$

τ representing the interval of time, A the star's altitude when on the prime vertical, and δ its declination; whence,

	$''$
ε *Bootis*	6.996
α *Corona Borealis*	6.931
30 *Leonis Minor*	6.910
β *Tauri*	6.945
α *Bootis*	7.026
Mean	arc $104''.43 = 6.962$

And the micrometer head making accurately four revolutions between the 7th and 8th wires, one revolution or

$$P = \frac{104''.43}{4} = 26''.107.$$

The interval between the 7th and 8th, and 8th and 9th wires, is four revolutions, and between any other two contiguous wires two revolutions of the micrometer head.

The telescope being moved to a horizontal position, the micrometer wire was made to bisect a terrestrial mark distant one and a half miles, and, the reading being noted, the wire was moved *north* 37".29. The south Y was then moved to the west, until the micrometer wire bisected the terrestrial mark as before.

OCTOBER 7, 1844.

The instrument having been moved in azimuth, its axis was levelled, the tube being to the north and vertical, object glass upwards:

North end.	South end.
32.6	29.6
32.6	29.7
32.7	29.7

Level reversed.

30.1	32.6
30.0	32.8
30.1	32.8
Sum 188.1 north.	Sum 187.2 south.

Sum 188.1 north.
Sum 187.2 south.

12)0.9

div. ″
0.075 = 0.105, north end high.

THE COMET-SEEKER.

PLATE X.

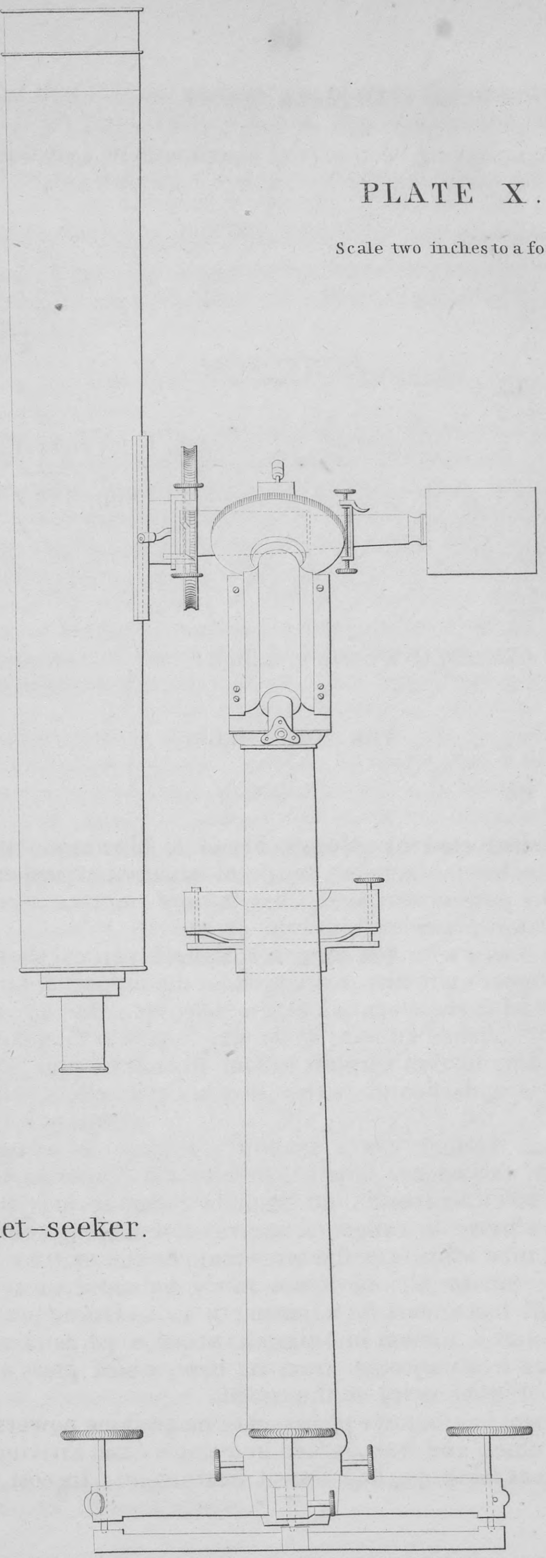
This was constructed by Messrs. MERZ & MAHLER. It has an object glass $3\frac{9}{10}$ inches in diameter, and focal length of 32 inches, with which low magnifying powers are used; that it may embrace a large field, and collect the greatest possible quantity of light.

A tripod of brass, with foot screws, sustains a vertical shaft of the same metal, whose upper extremity is enlarged for the support of an axis inclined at an angle equal to the elevation of the pole, viz: 38° 53′ 40″. To this is permanently attached an hour circle five inches in diameter, divided on silver, and reading by two verniers to four seconds of time, (1′). At right angles to this is a declination axis, fitted with its circle, which is of the same diameter as the preceding, and reads to minutes of arc by similar verniers. Each vernier has a magnifying glass to assist in reading. Threads cut in the edges, perpendicular to the planes of the circles, receive endless screws pressed into them by clamp-spring levers, and the endless screws serve as tangents to give slow motion about either axis. The telescope tube is made in the same manner and of the same materials as that of the equatorial, and is accurately balanced in every position. The brass shaft has a level for adjusting it to a vertical position, (by the foot screws,) and a motion in azimuth, about a perpendicular axis, by screws attached to a projection from its base, which press against a steel upright inserted into one leg of the tripod.

The instrument has four eye pieces, with magnifying powers from twelve to about fifty times, and was packed in a single case, arriving at the same time as the great telescope and transit instrument. Its cost was 700 florins—$280.

PLATE X.

Scale two inches to a foot



The Comet-seeker.

Two light, but firm, wrought-iron stands were made by Messrs. *T. W. & R. Smith*, and have been secured to the roof; one to the north, and the other to the south of the dome.

Two astronomical clocks have been ordered, one for the south and the other for the east wing; the former being the workmanship of Mr. Charles Frodsham, London; and the latter, Mr. William C. Bond, Boston. They cost $300 each.

THE MAGNETICAL INSTRUMENTS.

In the winter of 1842–'43, great diversity of opinion existed respecting the most suitable dimensions for magnetical instruments, and it was with difficulty I resolved to order any. Professor Gauss, at Göttingen, with 25-pound bars, was at one extreme; Dr. Lamont, at Munich, with needles 2½ inches long, made of a chronometer spring, and weighing about half an ounce, was at the other; whilst the committee of the Royal Society were intermediate. Professor Lloyd, of Dublin, considered that the size of the bars made for the English magnetical observatories could be advantageously reduced and mirrors substituted for the collimators; and Colonel Sabine and Professor Christie were of opinion, that small bars would eventually supersede all others. The little experience which I had obtained from two years of observation with the instrument made for me by Mr. Simms* induced me to lean towards light needles. I found that it passed from one position to a new one without vibration; that it indicated rapidly occurring changes in the directive force, which could not have been shown by a heavy bar from want of time to overcome the inertia; and that it afforded means of studying an occasional phenomenon, of which, to that time, I had seen no notice from observers with large bars, viz: a violent shivering, without azimuthal change, as though the needle had been suddenly struck on one end. Add to this, the necessity which had previously existed of making at least three readings, and reducing them, to obtain a position for a given epoch, whilst the light bar could be read at any instant; the great additional expense required for the erection of larger buildings, and the greater original cost of the instruments themselves; and it is not a matter of surprise that Dr. Lamont should have engaged so zealously in reforming existing defects.

On the other hand, uniformity was the great requisite in the investigation then prosecuting. Instruments, times, and modes of observation, were required to be as nearly identical as human skill could make them, else it would be legitimately questioned whether the results could be comparable. If the magnetical observatories were to be refitted, it is probable smaller instruments would be adopted; but as they were already equipped, if we wished to aid the cause, it was necessary like instruments should be procured, agreeing even in certain faults. The latter argument preponderated, and I deemed it advisable to copy the instruments made for the English observatories, differing from them only in points recommended by Professor Lloyd and Colonel Sabine.

* The needle was 13 inches long, 0.4 wide, and 0.05 thick. It was observed to 1″ by two micrometer microscopes. Time of vibration, 8″.46.

They were accordingly ordered from Mr. Barrow, (successor to Robinson,) and were made under the supervision of Lieutenant Riddle, R. A., assistant to Colonel Sabine.

DECLINOMETER.

"The frame work of the instrument consists of two pillars of copper, thirty-five inches in height, firmly screwed to a massive marble base. These pillars are connected by two cross pieces of wood, one at the top, and the other seven inches from the bottom. In the centre of the top piece is the suspension apparatus, and a divided circle used in determining the amount of torsion of the thread. A glass tube (between this and the middle of the lower cross piece) encloses the suspension thread, and a glass cap at top covers the torsion circle and suspension apparatus."

The box in which the magnet is enclosed is rectangular, and formed of burnished copper plates 0.2 inch thick; the box being 13 inches long by 3.9 inches in depth and width. It is secured to the marble slab, and is so arranged that it may be placed in two positions, at right angles to each other, as the reading telescope may be in the magnetic meridian or a plane perpendicular thereto. There are two apertures in the box, one in the end, the other in the side, each being in the same horizontal plane. The aperture in front is fitted with a copper dovetailed slide, glazed with plate glass 2 inches long and 1 inch wide, and that at the side is similarly glazed, the side of the box moving in a slide, that it may be reversed to detect any prismatic error. Both sides of the box are similarly arranged for removal, when adjusting the magnet bar. There is also a circular aperture in the top of the box, through which the suspension thread passes, and which is covered by a cylindrical slide passing within the glass tube.

This box is again enclosed by a case of deal or white pine, covered on both sides with gilded paper; the dimensions of the case being 15 inches long, 5½ inches wide, and 5½ inches deep. There are apertures opposite those of the inner box, closed also by dovetailed slides furnished with plate glass, and the case is fitted together in parts by small brass hooks.

The magnet bar is a rectangular parallelopiped, 12 inches in length, 0.85 inch in breadth, and 0.27 inch thick. It is suspended in a stirrup of brass, furnished with a mirror beneath, for the purpose of reading the declination changes by reflection, as proposed by Gauss. The mirror is attached to a cross, fixed to the stirrup, and is held in its place by the projecting heads of three screws, which serve also to adjust it. The mirror also revolves in a plane perpendicular to the axis of the magnet bar.

The suspension thread is composed of eight fibres of silk, as prepared for weaving, the upper end being secured to a screw moving nearly air-tight through the torsion plate, and the lower end attached to a small cylindrical bar of copper, fitted with a pin on one side, and a milled head screw-nut working freely round the bar. The suspension thread is raised or depressed by a nut, through which the screw in the torsion plate works, the action of this nut causing vertical motion in the screw, without torsion. A socket in the top of the stirrup receives the other extremity of the small bar, a groove being left for the pin on its side, and the milled head screw-nut secures the bar and stirrup together. There are also three small screws passing through the sides of the stirrup, by which the magnet is secured in its place.

For the purpose of taking out the torsion of the suspending thread, the instrument is furnished with a bar of gun metal of the same form and weight as the magnet, an aperture being left in its centre, in which a small magnet can be placed, to give a slight directive force, and facilitate the adjustment.

The graduated scales, supplied with the instruments, being too minute for distinct vision at so great a distance, I prepared others to be used temporarily, the magnitude of each division being nearly .047 of an inch; but, as some of the divisions vary perhaps $\frac{1}{6}$ of their space, it is desirable that more accurate ones should be drawn. Strong slips of cherry wood, 3 feet long, $2\frac{1}{2}$ inches wide, and $1\frac{1}{2}$ inches thick, were then secured to the piers by a band of brass, fitting closely in a groove of the moulding, the ends of which passed through the wood, and were fastened on the opposite side by screw nuts. The slips are cut into three pieces, the centre one, 18 inches long, being permanent; the others, each 9 inches long, folding back against the sides of the pier, except for extraordinary disturbances. The hinges which permit these to fold are let into the face of the wood, that, when in position, the scale presents a uniform surface. The scales were attached to these slips of wood with sealing wax varnish.

Below the scales, and of the same length with the central portion, (18 inches,) are mirrors, moving in quadrantal arcs about their axes of length, for the purpose of collecting and reflecting the light falling vertically on the scales.

The reading telescope has an aperture 1.7 inches, and focal length 21 inches, with a cross of wires at its focus. It is secured to the pier (the object glass vertical to the scale, at a distance of $\frac{1}{4}$ of an inch) by screws and nuts, the latter being cemented into the pier with sulphur. It is obvious, that only *changes* of the declination can be read with the telescope, unless the zero point be established by a second instrument, and used as a constant of reference. The construction of the building, too, prevents immediate reference to the heavens, for determining the direction of the astronomical meridian.

ADJUSTMENTS.

The instrument being placed on the pier in the south end of the cross, its base was carefully levelled.

The suspension thread was formed by laying together eight fibres of silk, without twisting, and fastened to the screw at the upper part of the tube and the cylindrical bar. A weight was then attached, (the thread being in its place,) for the purpose of removing a part of the torsion.

The stirrup, with the torsion bar inserted, was then attached, and the mirror adjusted, till the image of the scale, placed beneath the reading telescope, was reflected into the telescope, the bar having previously been made horizontal. Having come to rest, the deviation of the bar from the magnetic meridian was estimated, and the verniers of the torsion circle turned through the same angle, in an opposite direction.

A plumb line, suspended before the centre of the object glass of the reading telescope, was found to coincide with division 384.5, and the movable arms, or verniers of the torsion circle were turned until the division bisected by the vertical wire was 384.5. The torsion circle reading was then found to be $1^\circ\ 57'.\ 0$.

Removed torsion bar, and suspended magnet B No. 6. The magnet being adjusted to a horizontal position, the coinciding division of the scale was 482.3.

The value of one division of the scale being 33″ nearly, the interval for the arms of the torsion circle to be moved through is $482.3 - 384.5 = 97.8 \times 33'' = 53.'8$, and the verniers were accordingly moved to read $2^\circ 51'$.

The time of vibration of the magnet bar was found on the 27th September to be 11.″268, from a mean of 130 vibrations, its temperature at that time being 67.° 2.

Removed the magnet, and introduced the torsion bar; and after it came to rest, the reading was found to be 483. 0, showing that the plane of detorsion coincided very nearly with the magnetic meridian.

Moved the vernier of the torsion circle to 2° 51.′ 1; suspended the magnet in place of the torsion bar; and turned back the mirror to about the centre of the scale, the coinciding division at 0h. 30′ mean time Washington of September 27, 1844, being 333. 0.

BIFILAR MAGNETOMETER.

The marble base, copper pillars, connecting pieces of wood, enclosing boxes, magnet and torsion bars, scales and reading telescopes, are constructed in the same general manner and of the same dimensions as in the declinometer; the only points of difference being, that the deal case of the bifilar instrument is fifteen inches in breadth as well as in length, and there is an additional aperture in the tops of each, lined with velvet to render it air-tight, and which is intended for the insertion of a thermometer.

The magnet bar rests in a stirrup of gun metal, furnished with a mirror similar to the one described, and is suspended by a fine silver wire which passes round a small grooved copper or red metal wheel, and on the axis of which the stirrup rests by inverted Y's. The upper ends of the wires lie in the threads of a screw, one of them being secured to the upright, and the other passing round a roller, which serves to raise or depress the magnet. The intervals between the axes of the wires, corresponding to each wheel, have been determined by Mr. Barrow, by accurate micrometrical measurement; and the interval is altered at the upper extremity by means of two screws cut in the same cylinder, (one of which is right and the other left handed,) and a graduated head attached to the screw. The interval of the threads of this screw has also been accurately determined by the maker, and a revolution of the micrometer head is equal to .0256 of an inch; whence, the head being divided to one hundred parts, the value of a division is .000256, or rather more than the *two thousandth* part of an inch. The micrometer head was carefully adjusted by the maker, so that it was at zero on its receipt, the interval between the wires being exactly half an inch.

The micrometrical apparatus is connected with the verniers of a torsion circle, divided to single degrees, and reading by two verniers to 5′; the whole is covered with a glass cap, completing the enclosure of the instrument.

ADJUSTMENTS.

SEPTEMBER 25, 1844.

The instrument was placed on the pier in the eastern arm of the cross, and its base levelled. Wheel No. 10, whose diamter is 0.501 of an inch, was selected; the wire passed round it; a suspension formed of sufficient length for the tube, and the ends of the wire secured to their proper places in the roller. A small weight was then attached to the suspension, to keep proper tension on the wires, and the suspension put in its place, the apparatus resting on the divided torsion circle, and the wire hanging down the tube.

Placed the torsion bar in the stirrup, and suspended it. The interval of the wires at the upper and lower extremities differing by the quantity between the adjusted position of the micrometer and the diameter of the wheel, viz: 0.501 — 0.500; and the lower interval being the greatest, the spaces were equalized by turning the micrometer head forwards—

$$\frac{0.501 - 0.500}{0.000512} = + 1.9 \text{ divisions.}$$

Turned the arms of the torsion circle till its direction (*as estimated,*) coincided with the magnetic meridian. Secured the reading telescope to the pier; and screwed up the scale with its reflecting mirror. Turned about the mirror of the torsion bar, till the scale was seen reflected into the reading telescope, and the bar was allowed to come to rest.

The division of the scale coinciding with the vertical wire of the telescope was found to be 432.8. Removed the torsion bar, suspended and levelled the magnet bar B No. 2. Its reading was 433.5; and the verniers at that time (of the torsion circle) indicated 88° 55'. 0 and 268° 52'.5. Taking the difference of the scale readings 433.5 — 432.8, we have 0 div. .7, equal to about 23" arc. The plane of detorsion is therefore perpendicular to the magnetic meridian when the circle reads as above nearly, or accurately—

88° 54'.8
268° 52'.2

if the ratio of the torsion to the magnetic force differs but little from unity, as will be found is the case.

Moved the north end of the magnet bar towards the west, till the verniers read, respectively—

258° 54'.8
178° 52'.2

and removed the magnet. Suspended the torsion bar, and turned the mirror back through about 90°.

Suspended the magnet by the suspension of 8 fibres of the declinometer, and made the following horizontal vibrations, the temperature being 67°2

h.	'	"	"	h.	'	"	"
9	29	11.5		9	33	09.2	26.7
		38.0	26.5			35.7	26.5
	30	04.4	26.4		34	02.2	26.5
		30.2	25.8			28.5	26.3
		57.0	26.8			54.8	26.3
	31	23.5	26.5		35	21.5	26.7
		49.9	26.4			47.6	26.1
	32	16.4	26.5		36	14.0	26.4
		42.5	26.1			41.0	27.0

The above intervals being in sidereal time, if we take their mean 26''.441, and subtract the acceleration, we have 26''.3777 as the mean time of *two* vibrations, or 13''.1889 as the mean time of a single vibration.

SEPTEMBER 27, 1844.

The scale reading for the brass bar perpendicular to the magnetic meridian was observed 206.6. Suspended the magnet. The scale being thrown out of the field of view, the verniers of the torsion circle were turned till the same division of the scale coincided with the vertical wire of the telescope, viz: 206.6; when the vernier reading was found to be—

303° 04'.0
123° 01'.5

The difference of the vernier readings for the magnetic meridian 88° 54'.8 and 268° 52'.2, and the last is 145° 50'.8; through which angle it has been necessary to move the wires, in order to deflect the magnet to a position at right angles to the magnetic meridian. Taking the co-sine of 145° 50'.8, we have the ratio of the magnetic to the torsion force =.91781.

The mirror was then turned back to about the centre of the scale, and the coinciding division at 1h. 33'.0, mean time, Washington, was 325.8, and the adjustment was complete.

BALANCE MAGNETOMETER.

"The magnetic needle is 12 inches in length. It has a cross of wires at each end, attached by means of a small ring of copper; the interval of the crosses being 13 inches. The axis of the needle is formed into a *knife edge*, the edge of which passes as nearly as possible through the centre of gravity of the unloaded instrument. The weights by which the adjustments are effected are small brass screws moving in fixed nuts, one on each arm; the axis of one of the screws being *parallel* to the magnetic axis of the needle, and that of the other *perpendicular* to it,"—the object of the former is to bring the needle to a horizontal position; of the latter, to make the centre of gravity approach the centre of motion. There is also a mirror above the knife edges of the needle, whose plane is perpendicular to the magnetic axis, and which is held in place by a frame and three screw heads, serving to adjust it. The mirror is counterpoised by a permanent weight attached below the centre of gravity.

The needle rests by its knife edges upon agate planes attached to a solid support of copper, which is firmly fixed to a marble base. It is raised from the agate planes by means of a horizontal rectangular frame secured to the top of two upright pieces connected with the supporting stone. These are raised or lowered by an excentric piece passing beneath them, the excentric being made to revolve by a key. The whole is enclosed by an oblong box of deal, covered within and without by gilded paper, the box being 15 inches long and 7 inches high. An aperture is left in front, closed by a dovetailed slide fitted with plate glass, through which the mirror can be seen; there is also an aperture on each side opposite each end of the needle, and one on each side, through which the spirit level may be read. These are all fitted with parallel glass. A second box, similarly constructed, whose dimensions are, respectively, 17 inches, 5 inches, and

8.2 inches, encloses the first. There is also a circular aperture in the top of each box, for the insertion of a thermometer, the bulb of which is inside; and a spirit level attached to the marble base indicates any change of level the instrument may undergo.

In addition to the mirror for observing the changes of the needle by reflexion, there is a micrometer miscroscope opposite each end, supported on short pillars of copper firmly screwed to the marble base. They are so adjusted that one complete revolution of the micrometer head corresponds to 5 minutes of arc; and the micrometer head being divided into 50 parts, the arc corresponding to a single division is consequently 0'.1. There is likewise furnished a brass bar, of the same construction as the magnet, for determining the zero points of the micrometers; and a brass rod, also of the same length, the ends of which are graduated to 10', used in ascertaining the value of the micrometer divisions.

The reading telescope is of the same dimensions as the other two, and the value of the divisions of the scale about the same. To secure the latter to the pier, a casting of brass was made, fitting closely into the moulding of the cap to the pier; which casting was let into the slip of wood, and secured by screws. A brass frame, similar to the others, fits into three sides of a groove of the same moulding, and secures a bar passing through an aperture left for it in the cast. The pier would be shaken before the scale could be disturbed. This scale being vertical, a mirror on a movable joint, and travelling in a vertical slide, is used for reflecting the light upon it.

ADJUSTMENTS.

September 26, 1844.

The needle was suspended in the magnetic observatory, near the pier for its reading telescope, by *two* fibres of untwisted silk, and the following vibrations in a horizontal plane observed. One observer (Professor Coffin) noted the time by a sidereal chronometer, and a second (myself) observed the instant at which the needle passed a fixed point placed before it. The time of every tenth vibration only is noted. The temperature of the bar was 68.5°; barom. 30.236 in.; and arc of vibration from 20° to 5°.

'	"	'	"	
59	40.6	18	10.0	
01	22.0	19	50.6	12 vibrations.
03	03.0	21	50.0	
04	44.0	23	30.0	
06	24.7	25	10.5	
08	06.0	26	51.0	
09	46.5	28	31.2	
11	27.5	30	12.0	
13	08.0	31	52.8	8 vibrations.
14	48.5	33	12.6	
16	29.2			

The sidereal time of making 200 vibrations is therefore 33' 32".0; and the acceleration being for that interval 5".4937, we have $\frac{33'\ 32''.0-5''.4937}{200}$, $= 10''.0325$, the mean time of one vibration.

The needle was then placed on its agate planes, and vibrated vertically. As the time of vibration exceeded twenty seconds, and the needle came to rest in about twenty vibrations, the centre of gravity was evidently too much below the rotating point; and the weight, moving vertically, was changed till, by repeated trial, the time was made nearly the same as in the horizontal vibrations.

VERTICAL VIBRATIONS.

Professor Coffin observing the transit of the cross in the end of the needle, over the micrometer wire; time by the sidereal chronometer noted by myself. At 6m. P. M., Washington; temp. 67°.5; barom. as before. The time of each *second* transit is recorded.

h.	′	″	h.	′	″
18	17	28.2	18	22	47.0
	17	51.0		23	10.0
	18	14.0		23	32.5
	18	36.8		23	55.2
	18	59.5		24	18.0
	19	22.2		24	40.9
	19	45.0		25	03.3
	20	08.0		25	26.0
	20	30.2		25	48.5
	20	53.2		26	11.0
	21	16.2		26	33.5
	21	39.0		26	56.0
	22	01.2		27	19.2
	22	24.4		27	41.2

The sidereal time required for 54 vibrations is 10′ 13″.0; and the acceleration for this interval being 1″.6738, we have $\frac{10' 13''.0 - 1''.6738}{54} =$ 11″.3209, as the *mean* time of one vibration in a vertical plane, whose azimuth with the magnetic meridian, counted from north by east, was 92°.

The needle having been suffered to fall on the floor just previous to the last observations, it was deemed necessary to suspend and vibrate it again. *Two* fibres of silk were used, as before, at the same spot, and by the same means; the arc of vibration being from 10° to 5°, and the temperature 67°.4. Time of each *second* noted.

HORIZONTAL VIBRATIONS.

′	″	′	″
38	19.7	43	03.7
	40.0		24.2
39	00.0		44.2
	20.5	44	04.7
	40.7		25.0
40	01.0		45.0
	21.5	45	05.2
	41.8		25.5
41	02.0		46.0
	21.1	46	06.3
	42.5		26.5
42	02.9		46.7
	23.5	47	07.0
	43.7		

Fifty-two vibrations in $8' \; 47''.3$, sidereal time, subtracting $1''.4397$ for acceleration, there is $\frac{8' \; 47''.3 - 1''.4397}{52} = 10''.1127$, *mean* time of one vibration in a horizontal plane.

The instrument, being on the pier in the west arm of the cross, was fixed so that the north end of the bar was 90° 54′′ east of the magnetic meridian, and the base carefully levelled.

The brass needle was then placed on the agate planes, and the fixed wires of the microscopes adjusted to the same horizontal line, as follows: The movable wire of the eastern micrometer being made to bisect the cross in the end of the brass needle at rest, the needle was reversed, so that the end before to the west was now to the east. When its vibrations ceased, it was again observed with the eastern micrometer. The cross being found no longer bisected, the interval between the two positions of the bar was measured by the micrometer, and the wire moved through one-half. The end of the brass bar being moved through the other half, by means of a small adjusting weight attached to it, upon reversing it to the first position, the bisection continued; and the line joining the two crosses was therefore in the same horizontal plane. The movable wire of the west micrometer was made to bisect the cross in the west end of the bar, and the fixed wires moved to coincide with them, by means of the capstan headed screws at the lower part of the micrometer boxes.

To determine the accuracy of this adjustment, Professor Coffin made the following observations, the brass bar being reversed for each reading:

East micrometer.	West micrometer.
+ 0.10	— 0.05
— 0.03	— 0.20
+ 0.10	0.00
0.00	0.00
+ 0.15	— 0.03
— 0.03	0.00
+ 0.15	— 0.05

From which we obtain:

	East	West
	+ 0.06	— 0.13
	+ 0.07	— 0.10
	+ 0.05	0.00
	+ 0.07	— 0.01
	+ 0.09	— 0.01
	+ 0.09	— 0.03
Means	+ 0.07	— 0.05

or, zero of the east micrometer coincides with + 0.02 div. of the west micrometer.

SEPTEMBER 27.

The brass bar was removed, and the magnet bar placed on the planes. It being intended to observe the changes by reflexion, the needle was adjusted, so that a point about the centre of the scale was brought into the field of the telescope, and the reading at 6 P. M., mean time, Washington, was 268.3, the coinciding reading for the east micrometer being $+ 1' 00''$ and for the west micrometer $+ 4' 25''$. The instrument being adjusted, the outer box was placed over it, and the thermometer inserted.

FOX'S DEFLECTOR.

This is an ingenious instrument, invented by the gentleman whose name it bears, for the purpose of measuring the inclination and intensity; it was made for the observatory (under the direction of Colonel Sabine) by Mr. George, of Falmouth.

A brass tripod supports a circular horizontal plate, surmounted by a cylindrical box of brass, fixed upon a vertical axis ground into the centre of the tripod. The horizontal plate is graduated, and subdivided by verniers to 1'; the verniers being attached to the cylindrical box, and revolving with it. Upon this horizontal plate are spirit levels and clamp and tangent screws. One side of the cylindrical box is fitted with plate glass set in a frame, with a hinge and spring catch. Within the box there is a silvered vertical circle graduated to 10', and on the outside of the box, opposite the plate glass, is a second concentric circle, whose zeros, by construction, coincide with those of the interior circle.

The needle is supported by a concentric disc ground into the back, and a bracket attached to the disc, with axes resting in jewelled holes. To avoid interference in different magnetic latitudes, the disc with the bracket may be turned to any position desired; and the bracket may be loosed, for the removal of the needle, by the milled-head screw on the back of the box. There is also a contrivance by which the needle may be secured when not in use.

The exterior vertical circle has two radius bars terminating in verniers, near each of which there is a small screw hole, for the introduction of cylindrical magnet deflectors, enclosed in brass cases. A strong brass pin projects from the centre of the back, which is rubbed with an ivory disc during observation, to produce a slight vibratory motion of the needle, and a small thermometer, upon an ivory scale, is bent into a semicircular form, and secured within the box.

The instrument is furnished with three rhomboidal needles, one of which has been gilded. Upon an axis of each of them is a small grooved wheel. There is also a brass box containing silver weights from .05 of a grain upwards; silk loops, with hooks to attach the weight by, for placing in the grooved wheels; small cylindrical magnets to be used as deflectors; an ivory disc set in a handle; tweezers for handling the weights, and a reading glass.

There being no immediate use for this instrument, it was loaned to Professor Bache, for the survey of the coast of the United States.

A check or watch clock has been ordered for the magnetic observatory, from Mr. Aaron Willard, at Boston.

An ordinary clock is to be furnished with an extra train of wheels, carrying below the dial and inside of the case a disc of metal, which shall revolve in 24 hours. Upon the disc may be placed cards of paper, divided on the circumference into 24 parts. A lever, moving only in a direction vertical to the paper, holds a pencil on its inner extremity, which makes its mark on being touched from the outside. Marks being thus made at the record of the observations, afford evidence of the *times* when the assistants performed their duty. The case will of course be locked up, and a new paper introduced each day.

The reading telescopes have scarcely sufficient magnifying power, although Mr. Barrow was especially cautioned on the subject. He has since been written to, requesting that others might be furnished, and informed that those sent would be returned; but the letter has not been acknowledged. The execution of the declinometers does not give as great satisfaction as was anticipated.

METEOROLOGICAL INSTRUMENTS.

Standard barometer.—The cistern of this instrument is of glass, fitted into a bronzed frame of metal, which turns in a bracket attached to a mahogany board. The pivot of this frame is adjusted to a vertical position by three screws turning in the bracket. The tube is 0.580 of an inch in diameter. The frame supporting it is of brass, and the graduated scale is also of that metal, but silvered. The scale is divided to 0.05 of an inch position; reads, by means of a vernier, with a slow motion screw, to 0.002 of an inch, and slides up and down, by a slow motion screw, until its lower extremity is just in contact with the surface of the mercury in the cistern. The lower point is of ivory, and the adjustment is perfected when the ivory point and its reflected image are apparently in contact. The upper part of the frame terminates in a pivot, resting in a second bracket secured to the mahogany board.

The following comparisons were made on the 2d March, 1843, with the standard barometers of the Royal Society; the instruments hanging beside each other, and the temperature of the mercury being precisely the same in each:

Washington standard.	Royal Society' Crown glass.	Royal Society' flint glass.	R. Society' crown, —Washington.	R. Society' flint, —Washington.
Inches.	Inches.	Inches.	Inches.	Inches.
29.731	29.722	29.727	— 0.009	— 0.004
29.738	29.731	29.728	— 0.004	— 0.010
29.704	29.698	29.690	— 0.006	— 0.014

From these it appears that that the Washington standard reads more than the Royal Society's standard of flint glass by 0.006 inch, and more than their standard of crown glass by 0.009 inch. Cost of the barometer, £20.

Dry and wet bulb thermometer.—Two mercurial thermometers are attached to a silvered metallic plate, fitted upon a stand of wood. Each thermometer has its own scale, divided to half degrees. One of the bulbs is covered with a fine piece of muslin, and has a bundle of silk fibres connected with it, communicating with a fountain cistern of glass, held by springs between the two thermometers. A second cistern of brass has been attached below the wet bulb thermometer, to be used in frosty weather. Cost, £2.

Daniel's hygrometer.—This consists of a glass tube terminating in two bulbs, one of which is blackened on the inside and contains sulphuric ether, together with a small immersed thermometer, to indicate its temperature. The tube is bent to form two right angles, and is supported near its centre upon a brass stand, furnished also with a small thermometer. The transparent bulb is covered with a fine piece of muslin. Vapor being formed from ether at all temperatures, the temperature of that enclosed, is rapidly reduced by continued and quick condensation, produced by dropping some of the same liquid on the bulb covered with muslin, until the temperature of the air immediately in contact with it is so reduced that it can no longer sustain vapor, and it is deposited upon the black bulb. At the instant of its occurrence, a faint ring of dew appears on the black bulb, when the temperature of the enclosed thermometer is taken. Cost, £1 15*s.*

Self-registering thermometers.—Maximum thermometer.—This is a mercurial thermometer, whose tube is bent at a right angle, quite close to the bulb. It is fitted to a plate of brass, silvered, which is secured to a small mahogany board, and is suspended in a horizontal position by two rings. The scale is upon the silvered brass, and divided to 0°.5. The bulb is protected by a cylinder of brass, screwed to the mahogany board. The register is a piece of blue steel, moving freely within the tube, above the column of mercury, and moved along by its expansion. A small magnet serves to draw it back when the column has contracted. Cost, £1.

Minimum thermometer.—In form and size, this is precisely similar to the maximum thermometer. The bulb, however, is filled with spirit of wine, and the register is a float of colored glass, with a knob at each end. Cost, £1.

Solar radiation.—This is a spirit thermometer, with blackened bulb, and colored glass float for its register. The *tube* has been graduated so as to form its scale. Cost, 15s.

Radiation to the sky.—A spirit thermometer, with glass register, blackened bulb, *and divided upon the tube.* It is placed in the focus of a silvered parabolic reflector, fitted with a ball and socket upon a metallic stand. Cost, £2 10s.

Osler's Anemometer and rain gauge.—"A large vane, which is turned by the wind, and from which a vertical spindle proceeds down nearly to the registering table, gives motion by a pinion upon the spindle to a rack work carrying a pencil. This pencil makes marks upon a paper which is affixed to a board that is carried (by a chain connected with the barrel of a clock) in a direction transverse to the direction of the rack motion. The paper has lines printed upon it, corresponding to the positions which the pencil must take when the direction of the vane is N., E., S., or W.; and also has transversal lines corresponding to the positions of the pencil at every hour.

"For the pressure of the wind, the shaft of the vane carries a plate one foot square, which is supported by horizontal rods sliding in grooves, and is urged in opposition to the wind by three springs, so arranged that only one comes into play, when the wind is light, and the others act successively, in conjunction with the first, as the plate is driven farther and farther by the force of the wind. A cord from this plate passes over a pulley, and communicates with a copper wire passing through the centre of the spindle, which at the bottom communicates with another cord passing under a pulley, and held tight by a slight spring; and this moves a pencil transversely to the direction in which the paper fixed to the board is carried by the clock. Lines are printed upon the paper, corresponding to different values of the pressure; the intervals of these lines were adjusted by applying weights of 1 pound, 2 pounds, &c., to move the pressure plate in the same manner as if the wind pressed it.

"The rain gauge is connected with the anemometer, and (its horizontal dimensions being 10 by 20 inches) it exposes to the rain an area of 200 square inches.

"The collected water passes through a tube into a vessel suspended in a frame by spiral springs, which lengthen as the water increases, until .25 of an inch is collected in the receiver: it then discharges itself by means of the following modification of the syphon. A glass tube, open at both ends, is fixed in the receiver, in a vertical position, with its end projecting below the bottom. Over the top of this tube, a larger one, closed at the top, is placed loosely. The smaller tube thus forms the longer leg, and the larger tube the shorter leg of the syphon. The water having risen to the top of the inner tube, gradually falls through into the uppermost portion of a tumbling bucket, fixed in a globe under the receiver. When full, the bucket falls over, throwing the water into the pipe at the lower part of the globe: this action causes an imperfect vacuum in the globe, sufficient to cause a draught into the longer leg of the syphon, and the whole contents run off. After leaving the globe, the water is received in a pipe attached to the building, which carries it away. Then the springs shorten, and raise the receiver. The ascent and descent of the water vessel move a radius bar, which carries a pencil; this pencil makes a trace upon the paper carried by the sliding board of the self-registering anemometer."

The anemometer obtained for the depôt, for want of a suitable eminence, has not been mounted, and the preceding description is taken from the volume "*Magnetical and meteorological observations. Greenwich,* 1840 and 1841."

I directed Mr. Newman to add to this instrument a leather band, by which the motion of the clock might be communicated to the sliding table, should the chain ordinarily furnished be found inefficient, and to give greater range to the low pressures; both which were complied with. The springs will indicate from 0 pounds to 25 pounds the square foot. Its cost was £52.

The principal objections urged against the anemometer, as constructed by Newman, are, that there being ordinarily but little force or pressure of the wind, if the instrument is rendered sensitive to it, it is of little value in high winds; that the pencil recording the *direction* is liable to be thrown out of gear by the turning of the vane; and that no provision is made for measuring the snow. Professor Bache stated, at the centennial meeting of the Philosophical Society, in 1843, that he had obviated all the difficulties in the instrument erected by him at the Girard College, and that its performance was all that could be desired.

THE LIBRARY.

To a list of the astronomical books contained in the library at the High School Observatory, Philadelphia, (for which, and many most valuable suggestions, I am under great obligations to Mr. S. C. Walker,) such additions were made by Messrs. Airy, Schumacher, Encke, and Lamont, as they deemed most essential in beginning a library; and the English, French, and German publications, were purchased at London, Paris, and Leipsic respectively. Professor Schumacher advised that the Italian books should be ordered direct from the Mediterranean, as the freight and duties would quite double the cost at either of the cities named, and they were accordingly erased from the catalogue.

Many of the most costly books were obtained at stores, where only second hand copies are sold, and at sums varying from one-eighth to one-fourth of their original prices. Thus: the Philosophical Transactions abridged, originally published at *thirty-nine guineas*, was bought for *five pounds sterling;* and the Philosophical Transactions *at large*, from 1800 to 1838, inclusive, published at £97, was bought for £25. Both copies were new, the leaves being uncut.

Much interest was evinced in the success of the naval observatory by the distinguished *savans* I had the honor to meet; and, in token of their gratification at the establishment of an institution by the United States, where science will be prosecuted, they have contributed to its library the following books.

BOOKS PRESENTED.

By the Royal Society.

Philosophical Transactions, 1843, *et seq.*, 2 vols. 4to.
Monthly Notices, 1843, *et seq.*, 8vo.
Annales Magnetique, &c., par Kupffer, 2 vols. 4to.
Greenwich Magnetical and Meteorological Observations, 1 vol. 4to.
List of Fellows Royal Society, 1 vol. 4to.

Royal Astronomical Society.

Memoirs of the Astronomical Society, 15 vols. 4to.
Monthly Notices, 5 vols. 8vo.
Pond's Catalogue of Stars, 1 vol. folio.
Johnson's Catalogue of Stars, 1 vol. 4to.
Greenwich Observations, 2 vols. 4to.
Greenwich Observations, part 5, for 1833, 1 vol. folio.
Edinburgh Observations, 4 vols. 4to.
Cambridge Observations, 1 vol. 4to.

Astronomer Royal, Greenwich.

Cambridge Observations, 1828 to 1835, inclusive, 8 vols. 4to.
Greenwich Observations, 1836 to 1840, inclusive, 5 vols. 4to.
Appendix to Observations, 1836 and 1837, 2 vols. 4to.
Rates of Chronometers on trial, 1 vol. 4to.

Astronomer Royal, Berlin.

Berlin Observations, vol. 1st, 1 vol. folio.
Venusdurchgung, 1 vol. 4to.

Astronomer Royal, Brussels.

Annales de l'Observatoire de Bruxelles, 1 vol. 4to.
Catalogue des Principales Apparations des Etoiles Filantes, 1 vol. 4to.
Nouveau Catalogue, do., 1 vol. 4to.
Observations des Phénoménes Périodiques, (pamphlet,) 4to.
Résumè des Observations, &c., (pamphlet,) 4to.
Notes sur les Instruments Météorologiques, (pamphlet,) 4to.
Résumè des Observations sur, &c., (pamphlet,) 4to.
Sur la Difference de Longitude, &c., (pamphlet,) 4to.
Receuil d'Observations, &c., 1 vol. 8vo.
Statistique et Météorologique, (pamphlet,) 8vo.
Instructions pour l'Observation, &c., (pamphlet,) 4to.
Longitude de l'Observatoire de Bruxelles, (pamphlet,) 4to.

Astronomer Royal, Munich.

Astronom. Beobachtungen in München, 12 vols. 4to.
Uber die Nebelflecken, 1 vol. 4to.
Uber das Magnetische, 4to.
Observatorium der Königlichen Sternwarte, &c., 4to.
Jahrbuch der Koëngs Sternwarte, 5 vols. 8vo.
Annalen für Meteorologie und Erd-Magnetismus, 1840, *et seq.*, 4 vols. 8vo.
Bestimmung der Horizontalischen Intensität, 1 vol. 4to.

Professor Challis, Cambridge Astronomer.

Cambridge Observations, 1836 to 1840, 5 vols. 4to.

Professor Mädler, Dorpat Astronomer

Dorpat Observationen, *et seq.*, 8 vols. 4to.
Knorre. Ort des Polarsterns, 1 vol. 4to.
Preuss. Beobachtungen auf der Reise, &c., 1 vol. 4to.
Struve. Catalogus Novus, &c., 1 vol. folio.
Struve. Gradmessung, 2 vols. 4to.
Gassendi. (Lunar mountain) drawing of.
Meteorological observations, graphically illustrated.

Professor Kreil, Prague Astronomer.

Magnetische und Meteorol. Beobach. zu Präg., *et seq.*, 3 vols. 4to.

M. Johnson, Oxford Astronomer.

Oxford Observations, 1841 and 1842, *et seq*, 2 vols. 8vo.

English Admiralty.

Nautical Almanac, from 1767, 40 vols. 8vo.
Selections from Additions to do., 1 vol. 8vo.
Tables requisite to be used with do., 1 vol. 8vo.

Longitudes and Latitudes Venus and Jupiter, 1 vol. 4to.
Bernouilli's Sexcentenary Tables, 1 vol. 4to.
Taylor's Sexagesimal Tables, 1 vol. 4to.
Bayer's Tabulæ Motuum Solis et Luna, 1 vol. 4to.
Tables for Correcting App. distances Moon and Star, 1 vol. 4to.
Tables of Moon's Distances from Sun and Stars, 1 vol. folio.
Mayer's Theoria Lunæ, 1 vol. 4to.
Hutton's Products and Powers of Numbers, 1 vol. folio.
Astronomical Observations made in a voyage towards the south pole, 1 vol. 4to.
Astronomical Observations made in the Southern Hemisphere, 1 vol. 4to.
Astronomical Observations made in the North Pacific Ocean, 1 vol. 4to.
Principles of Mr. Harrison's Time Keeper, 1 vol. 4to.
Account of the going of do., 1 vol. 4to.
Bird's Method of Dividing Astronomical Instruments, 1 vol. 4to.
Description of an Engine for Dividing Straight Lines, 1 vol. 4to.
Description of Ramsden's Engine for Dividing Mathematical Instruments, 1 vol. 4to.

Captain Beaufort, R. N., Hydrographer, &c.

Greenwich Observations, part 5, 1829, 1 vol. folio.
Do do part 5, 1830, 1 vol. folio.
Do do vols. 1831 and 1832, 2 vols. folio.
Do do parts 1, 2, 3, 4, 1833, 4 vols. folio.
Do do vols. 1834 and 1835, 2 vols. folio.

Honorable East India Company.

Madras Observations, 5 vols. 4to.

Rev. R. Sheepshanks, F. R. S., &c.

Report of Special Commission on Restoring Standard of Length, &c., 1 vol. 4to.
Logarithmic tables on cards.

Rev. H. Lloyd, D. D., F. R. S., &c.

Account of Dublin Magnetical Observatory, 1 vol. 4to.
Induction Inclinometer, (pamphlet,) 8vo.
Mutual Action Permanent Magnets, 4to.

The Authors.

Report of the Poor Law Commissioners, 1 vol. 8vo.

W. J. Frodsham, F. R. A. S., &c

Eiffe's Improvements in Chronometers, 1 vol. 4to.
Experiments on Pendulums, 1 vol. 4to.
Observations on Chronometers, 1 vol. 8vo.

The Washington Naval Observatory has been placed on the list of correspondencies, and will be presented with the following publications hereafter:

Philosophical Transactions.
Memoirs Royal Astronomical Society.
Greenwich Observations.
Cambridge Observations.
Oxford Observations.
Edinburgh Observations.
Dorpat Observations.
Munich Observations.
Prague Observations.
Brussels Observations.
Hamburg Observations.
Madras Observations.
Berlin Observations.
Annals Magnetism and Meteorology.

BOOKS PURCHASED.

Adams's Astronomy, 1 vol. 8vo.
Adams's Electricity, 1 vol. 8vo.
Airy. Gravitation, 1 vol. 8vo.
Airy. Tracts, 1 vol. 8vo.
Airy. On Correcting Compasses in iron ships, 1 vol. 4to.
Baily. Flamstead, 1 vol. 4to.
Baily. Astronomical Tables, 1 vol. 8vo.
Babbage. Tables of Logarithms, 1 vol. 8vo.
Barlow. Theory of Numbers, 1 vol. 8vo.
Barlow. Tables of Logarithms, 1 vol. 8vo.
Barlow. Mathematical Dictionary, 1 vol. 4to.
Bayeri. Tabulæ, 1 vol. 4to.
Bonnycastle. Astronomy, 1 vol. 8vo.
Bradley's Life and Miscellaneous Works, 1 vol. 4to.
Bradley. Astronomical Observations, 2 vols. folio.
Brett. Astronomy, 2 vols. 8vo.
Brewster. Terrestrial Magnetism, 1 vol. 8vo.
Coles. On Comets, 1 vol. 8vo.
Dalton. Meteorological Essays, 1 vol. 8vo.
Falconer. Marine Dictionary, 1 vol. 4to.
Flamstead. Atlas Celestis, 1 vol. folio.
Foster. On the Atmosphere, 1 vol. 8vo.
Frome. Trigonometrical Surveying, 1 vol. 8vo.
Gregory. Astronomy, 1 vol. 8vo.
Gregory. Miscellaneous Works, 2 vols. 8vo.
Halfte. Astronomy, 1 vol. 4to.
Hancock. Comets, 1 vol. 8vo.
Herschell. Catalogue of Stars, 1 vol. folio.
Hevelius. Selenographia, 1 vol. 4to.
Hutton.
Hygini.
Jamieson. Mechanics of Fluids, 1 vol. 8vo.

Jamieson.
Kepleri. Opera.
Kepler. Epitome, 1 vol. 8vo.
Kitchener. On Telescopes, 1 vol. 8vo.
Lubbock, (Sir John.) Tracts, 1 vol. 8vo.
Ludlam. Observations, 1 vol. 4to.
Longomontanus.
Lorimer. On Magnetism, 1 vol. 4to.
Lynn. Practical Methods, 1 vol. 4to.
Maskelyne. Astronomical Observations, 1 vol. folio.
Melanderhjelm.
Meteorology. Quarterly Journal of, 1 vol. 8vo.
Mudge. Trigonometrical Survey, 4 vols. 4to.
Murphy. Rudiments, 1 vol. 4to.
Mylne. Astronomy, 1 vol. 8vo.
Nautical Almanac, 25 vols. 8vo.
Parry. Nautical Astronomy, 1 vol. 4to.
Penny Cyclopedia, 27 vols. 8vo.
Philosophical Transactions Abridged to 1800, 18 vols. 4to.
Philosophical Transactions at Large, 43 vols. 4to.
Pond. Astronomical Observations, 1811, 1812, 1813, 1820, 1823, 1827, and 4 parts 1830, 7 vols. folio.
Raper. Navigation, 1 vol. 8vo.
Reid. On Storms, 1 vol. 4to.
Reports. British Association, 10 vols. 8vo.
Robinson. Astronomical Observations, 3 vols. 4to.
Taylor. Logarithms, 1 vol. 4to.
Trattato. Della Sphera, 1 vol. 8vo.
Tychonis. Brahei, 1 vol. 4to.
Whiting. Astronomy, 1 vol. 4to.
Whewell. Inductive Sciences, 3 vols. 8vo.
Wing. Ephemerides, 1 vol. 4to.
Woodhouse. Astronomy, 3 vols. 8vo.
Zach. Tavole, 1 vol. 4to.

Annuaire. Bureau de Longitude, 19 vols. 12mo.
Anquetil. Questions sur l'Astronomie, 1 vol. 8vo.
Atlas. Des Phénomènes celestes 1843, 1 vol. 4to.
Bagay. Tables Astronomiques, 1 vol. 4to.
Bernoulli. Recherches Astronomiques, 1 vol. 4to.
Berthoud. Essai sur l'horologie, 2 vols. 4to.
Berthoud. Suite des Montres à longitude, 1 vol. 4to.
Bezout. Traite de Navigation, 1 vol. 8vo.
Bezout. Notes et additions, 1 vol. 8vo.
Biot. Refractions extraordinaires, 1 vol. 4to.
Biot. Astronomie physique, 2 vols. 8vo.
Biot. Tables Barometriques, 1 vol. 8vo.
Biot & Arago. Receuil d'observations, 1 vol. 4to.
Biot & Arago. Affinité des corps celestes, 1 vol. 4to.
Bion. Instruments de Physique, 1 vol. 4to.
Bigot de Morogues. Chutes des pierres, 1 vol. 4to.
Borda. Tables Trigonometriques, 1 vol. 4to.

Boscovich. Voyage astronomique, 1 vol. 4to.
Bourdé. Le Manœuvrier, 1 vol. 8vo.
Burckhardt. Tables de Logarithms, 1 vol. 4to.
Burckhardt. Tables de la Lune, 1 vol. 4to.
Cagnoli. Catalogue de 501 Etoiles, 1 vol. 4to.
Cassini. Astronomie, 2 vols. 4to.
Cassini. Jonction des Observatoires, &c., 1 vol. 4to.
Cassini. Mèridienne de Paris verifiée, 1 vol. 4to.
Clairault. Figure de la Terre, 1 vol. 8vo.
Clairault. Theorie de la Lune, 1 vol. 4to.
Clos. Apperçu sur la Météorologie, 1 vol. 8vo.
Comptes-rendus des Seances de l'Institute, &c., 18 vols. 4to.
Connoissance de Tems 1810 to 1846, inclusive, 37 vols. 8vo.
Cotte. Traite de Météorologie, 1 vol. 8vo.
Coulomb. Mémoire sur l'Electricité, 1 vol. 4to.
Cousin. Introduction à l'Astronomie, 1 vol. 4to.
Dalembert. Précession des equinoxes, 1 vol. 4to.
Dalembert. Cause des Vents, 1 vol. 4to.
Damoiseau. Tables des Satellites de Jupiter, 1 vol. 4to.
Damoiseau. Tables de la Lune, 1 vol. folio.
Daquin. Essais Météorologiques, 1 vol. 4to.
Delambre. Astronomie pratique, 3 vols. 4to.
Delambre. Astronomie ancienne, 2 vols. 4to.
Delambre. Astronomie moyen-âge, 1 vol. 4to.
Delambre. Astronomie moderne, 2 vols 4to.
Delambre. Astronomie 18 siècle, 1 vol. 4to.
Delambre. Determination d'un arc, &c., 1 vol. 4to.
Delambre & Burg. Tables du Soliel, 1 vol. 4to.
Delambre & Burg. Tables Eclyp. des Satellites de Jupiter, 1 vol. 4to.
Deluc. Modifications de l'Atmosphere, 4 vols. 8vo.
De Zach. Tables de la Lune, 1 vol. 8vo.
De Zach. Tables du Soliel, 1 vol. 8vo.
De Zach. Tables d'aberration, 1 vol. 8vo.
De Zach. Fixarum Prœcipanrum, 1 vol. 4to.
Dien. Description et l'usage de l'Uranographie, 1 vol. folio.
Dubourget. Traite de Navigation, 1 vol. 4to.
Dubreuil. Manuel de Matelotage, 1 vol. 8vo.
Fabré. Traité du Nivellement, 1 vol. 4to.
Francœur. Astronomie pratique, 1 vol. 4to.
Francœur. Uranographie, 1 vol. 8vo.
Francœur. Traité de Géodésie, 1 vol. 8vo.
Gamasches. Astronomie physique, 1 vol. 4to.
Garniér. Traitè de Météorologie, 1 vol. 8vo.
Gicquel Destouches. Tables comparatives, 1 vol. 4to.
Hennet. Le globe celeste, 1 vol. 8vo.
Humboldt. Receuil d'observations, 2 vols. folio.
Jurgensen. Horlogerie exacte, 1 vol. 4to.
Izarn. Lithologie atmospherique, 1 vol. 8vo.
Janvier. Revolution des corps célestes, 1 vol. 4to.
Keil. Introductionis in verram, &c., 1 vol. 8vo.
Lacaille. Astronomica fundamenta, 1 vol. 4to.
Lacaille. Cœlum Australe, 1 vol. 4to.

Lalande. Histoire céleste française, 1 vol. 4to.
Lalande. Bibliographie astronomique, 1 vol. 4to.
Laplace. Précis d'Astronomie, 1 vol. 8vo.
Legendre. Determination des orbites des Comêtes, 1 vol. 4to.
Lemonier. Institutions Astronomiques.
Lepaute. Traité d'Horlogerie, 1 vol. 4to.
Loupot. Eléments d'Astronomie, 1 vol. 8vo.
Mairan. Aurore Boréale, 1 vol. 4to.
Maupertuis. Figure de la Terre, 1 vol. 8vo.
Maupertuis. Astronomie Nautique, 1 vol. 8vo.
Mollet. Gnomonique graphique, 1 vol. 8vo.
Mollet. Etude du ciel, 1 vol. 8vo.
Observations Astronomiques á l'observatoire de Paris, 2 vols. folio.
Olivier. Essai sur les Comêtes, 1 vol. 8vo.
Operations Géodésique du Piemont, 3 vols. 4to.
Pontécoulant. Systéme du Monde, 4 vols. 8vo.
Pontécoulant. Comête de Halley, 1 vol. 12mo.
Pingré. Cométographie, 2 vols. 4to.
Puissant. Géodesie, 2 vols. 4to.
Puissant. Topographie, 1 vol. 4to.
Quinet. Variations Magnetiques, 1 vol. 8vo.
Ramond. Formules Barometriques, 1 vol. 4to.
Robert. Comparison des Chronomêtres, 1 vol. 4to.
Sedillot. Instruments Astron. des Arabes, 2 vols. 4to.
Saussure. Hygrométrie, 1 vol. 4to.
Tables. Barometriques, 1 vol. 8vo.
Table. A sept decimales, 1 vol. 12mo.
Tables. De Jupiter et de Saturne, 1 vol. 4to.
Tavole delle parallassi di altezza, &c., 1 vol. 4to.
Tofino. Observationes Astronomicæ hechas in Cadix, 2 vols. 4to.
Van-beck. Influence du fer, 1 vol. 8vo.
Van Swinden. Analogie de l'Electricité, at Magnetisme, 3 vol. 8vo.
Vega. Tabulæ Logarithmo Trigonometrica, 1 vol. 4to.
Vega. Thesaura Logarithmorum, 1 vol. folio.

Argelander. Astronomische Beobachtungen, 3 vols. folio.
Argelander. 560 Sterne, 1 vol. 4to.
Argelander. Untersuchungen, 1 vol. 8vo.
Bær & Mädler. Der Mond, 1 vol. 4to.
Bær & Mädler. Mondkarte, 1 vol. folio.
Berliner Jahrbuch. (Complete) 76 vols. 8vo.
Bessel. Astronomische Beobachtungen, 19 vols. folio.
Bessel. Untersuchungen, 1 vol. 8vo.
Bessel. Bestimmung der Länge, 1 vol. 8vo.
Bessel. Bohn der Cometen, 1 vol. 8vo.
Bessel. Tabulæ Regiomontanæ, 1 vol. 8vo.
Bessel. Vorrücken der Nachtgleichen, 1 vol. 8vo.
Bessel. Fundamenta, 1 vol. 4to.
Benzenberger. Bestimmung der länge, 1 vol. 8vo.
Bohnenberger. Zeitschrift für Astronomie, 3 vols. 8vo
Bohnenberger. Astronomie, 1 vol. 8vo.
Crelle. Rechentafeln, 1 vol. 4to.

Struve. Additamentum, &c.
Encke. Entfernung der Sonne, 1 vol. 4to.
Encke. Venus Durchgang, 1 vol. 4to.
Gauss. Theoria motuum corpoum, 1 vol. 4to.
Hallascha. Elementa, 1 vol. 4to.
Hansen. Fundamenta quam Luna, 1 vol. 8vo.
Hansen. Störung der Jupiter und Saturn, 1 vol. 4to.
Harding. Atlas Celestis,† 1 vol. folio.
Lamont. Nebelflecken, 1 vol. 4to.
Littrow. Astronomische Beobachtungen, 19 vols. folio.
Littrow. Theoretische et practische Astronmie, 3 vols. 8vo.
Littrow. Calendariographie, 1 vol. 8vo.
Littrow. Vorlesungen, 1 vol. 8vo.
Littrow. Sonnenfinsterniss, 1 vol. 8vo.
Littrow. Wahrscheinlichkeitsrechnung, 1 vol. 8vo.
Nicolai. Wegweiser, 1 vol. 8vo.
Olbers. Berechnung der Cometen, 1 vol. 4to.
Schrœter. Beiträge, 1 vol. 8vo.
Schrœter. Entdeckungen, 1 vol. 8vo.
Schubert. Populaire Astronomie, 3 vols. 8vo.
Schumacher. Astronomische Nachrichten,† 19 vols. 4to.
Schumacher. Astronomisches Jahrbuch, 8 vols. 8vo.
Struve. Astronomiche Beobachtungen, (Dorpat,) 7 vols. 4to.
Verzeichniss der Beobachtungen der Sterne auf Veranlassung, (Stundenkarte,) 2 vols. folio.
Zach. Monatliche Corrrespondenz, 28 vols. 8vo.
Zach. Geographische Ephemiriden, 31 vols. 8vo.

Books since ordered from London.

Greenwich Observations, to complete the copy.
Edinburgh Observations, vol. 1., do.
London Journal of Sciences.
London Athenæum.
London and Edinburgh Philosophical Journal.
Quarterly Journal Meteorological Science, (discontinued.)

From Paris.

Addenet. Nouvelle Theorie de l'Electricité.
Bertot. Theorie de quelques actions moléculaires de la lumiere.
Congrés Scientifique de France.
Dien. Orbit apparente de la Comĕte, 28 Octobre, 1842.
Dien. Orbit apparente de la Comĕte, 3 Mai, 1843.
Dien. Atlas du Zodiaque.
Dien. Mésures micrometriques des Etoiles doubles.
Effemeridi di Milano, 1843 and 1844.
Explication et Histoire du puits de Grenelle.
Lalanne. Cours complét de Météorologie.
Struve. Catalogue de 514 Etoiles doubles.

---

* The last copy in possession of Harding's widow.
† The first volume is entirely out of print.

Voyage de la Commission scientifique du Nord.

From Hamburg.

Annalen der Sternwarte in Wien, vol. 20, *et seq.*
Annalen der Sternwarte in Königsberg, vol. 20, *et seq.*
Annalen der Sternwarte in Abœ, vol. 4, *et seq.*
Annalen der Sternwarte in Dorpat, vol. 8, *et seq.*
Annalen der Sternwarte in Berlin, vol. 2, *et seq.*
Annalen der Sternwarte in Pulkova, vol. 1, *et seq.*
Berliner Jahrbuch, 1846.
Stundenkarte der Akademie der Wissenschaften, und in Berlin Stunde, 1, 3, 5, 7, 9, 11, 13, 16, 20, 21, 24, (O.)

The duties assigned me by the department are thus terminated; but I sincerely hope that it will not be regarded presumption, if I offer a few remarks respecting the future labors of the observatory, urging, as my apology, the interest I feel in an establishment whose immediate existence is due partly to myself. To place this in its proper light, I must briefly revert to the history of the depôt, and the progress of astronomical observations under the directions of the department.

Through the influence of Lieutenant L. M. Goldsborough, (now a commander,) a bureau was established in this city, in 1830, for the care of the instruments, charts, &c., of the navy. One of the duties of the officers connected with it was the careful rating of all chronometers belonging to the navy, which was for some months effected by sextant and circle observations; but, between the summers of 1831 and 1833, with a thirty-inch transit instrument made in New York by Mr. R. Patten. The transit was mounted within a small circular building, upon a brick pier, having a base about 20 feet below the surface. To Lieutenant Goldsborough, therefore, is due the erection of the first astronomical instrument for the navy at Washington.

He was succeeded in the charge of the depôt, in 1833, by Lieutenant Wilkes, (now commander,) who obtained permission from the Navy Commissioners, and removed the office from its then location in the western end of Washington, to Capitol hill, about 1,000 feet N. 5° W. from the dome of the Capitol, where it remained till July, 1842. Here Lieutenant Wilkes erected (at his own expense) an observatory 16 feet square, and mounted one of the 5-feet transits made by Troughton for the coast survey in 1815, which was loaned by Mr. Hassler for the purpose.

I do not find that any regular series of observations were commenced until the departure of the exploring expedition in 1838, the principal use made of the transit being the determination of time. This was a daily requisite, as the comparing clock performed irregularly, and was not to be relied on more than 24 hours, nor was it possible to procure proper instruments exclusively for the use of the depôt.

During the absence of Lieutenant Wilkes in Europe, to purchase instruments for the exploring expedition, Lieutenant Hitchcock took charge of the depôt, and I was ordered as his assistant in November, 1836, and left in charge in the following spring, on the appointment of Lieutenant Wilkes to the survey of George's shoal. In the winter of 1837–'38, whilst he was surveying the entrance to Savannah river, I observed, at his request, all the culminations of the moon and stars tabulated with it, which occurred before midnight, but the observations were never reduced. When he accepted the command of the exploring expedition in 1838, the importance of corresponding moon-culminations, occultations, and eclipses, in determining differences of longitude with the expedition, were suggested to the department, and Mr. William C. Bond, at Boston, and myself, were directed to continue such observations during its absence.

These instructions enabled me to obtain a portable 42-inch achromatic telescope, mounted parallactically; a variation transit, modified from Gamby's plan, so as to be used as a diurnal instrument in the bi-hourly observations; an 8-inch dip circle, and a sidereal chronometer; and the observations commenced September, 1838.* From that time till the return of the expedition, in June, 1842, I observed every culmination of the moon, and every occultation visible at Washington, which occurred between two hours before sunset and two hours after sunrise. (The transit was extremely deficient in optical power, and would not define stars smaller than the second magnitude when the sun was two hours above the horizon.) The number of transits recorded exceeds 10,000, embracing the moon, planets, and about 1,100 stars, and it is hoped their reduction will be completed next summer. The average annual number of culminations of the moon observed was 110, and of lunar occultations about 20.

As the observations progressed, the unsuitableness of the building, the defects of the transit instrument, the want of space to erect a permanent circle, and the absolute necessity of rebuilding the observatory in use, became each day more urgent, and, at my earnest solicitation, the Commissioners of the Navy recommended an appropriation for a permanent establishment, in December, 1841. Even this, however, was not accomplished without difficulty. But the efforts of the then honorable Secretary to advance science, and more especially those branches of it in which the navy is interested, are well known to the country; and immediately appreciating its importance, he brought the subject before Congress in his report to the President of December, 1841.

Much delay occurred with the Naval Committees in Congress. The Hon. Francis Mallory, to whom it was referred by the House committee, espoused the cause warmly, but the majority kept aloof from the depôt (although so near) until the entire winter passed away. Finally, on the 15th March, 1842, I succeeded in persuading the only member of the committee to visit the observatory who was skeptical, and on that very day a unanimous report and bill were presented to the House of Representatives. Believing the chances of success would be greater if a bill could be passed by the Senate, by the advice of Mr. Mallory, I waited on the Naval Committee of the Senate, but my entreaties for a personal inspection of our wants were put off from time to time. The question was probably decided by an astronomical event.

At a meeting of the National Institute, at which the Hon. William C. Preston was present, I gave notice of having found Encke's comet with the 3½ feet achromatic, the comet being then near its perehelion. A few days subsequently, I made what was intended to be a last visit to the

* Two clocks, a sidereal, and a mean time, and a balance magnetometer, were subsequently obtained.

chairman of the Senate committee, and found Mr. Preston with him. As soon as I began the conversation about the little observatory, Mr. Preston inquired whether I had not given the notice of the comet at the institute, and immediately volunteered, "I will do all I can to help you." Within a week, a bill was passed by the Senate.

It is hardly necessary to trace its progress in the House. A majority was known to be favorable, but its number on the calendar, and the opposition of one or two members, were likely to prevent action upon it; and that it did receive the sanction of the House of Representatives at the las hour of the session of 1841–'42, the navy is indebted to the untiring ex ertions of Dr. Mallory.

Add to this, that the plans and direction of all the work to the presen time has been under my control, and I can scarcely be accused of vanity, in claiming to feel a greater interest in the successful prosecution of the observations than any other person. In the mere store rooms for the charts and instruments, or depôt, as it is called, I feel no anxiety. The house on Capitol Hill would have answered quite as well as any other, and a three and a half feet transit, in a box ten feet square, would have served to obtain the time for the comparing clock. These, therefore, possessed no attractions for me, and I should have regarded it as time misspent to labor so earnestly only to establish a *depôt.* My aim was higher. It was to place an institution under the management of *naval officers,* where, in the practical pursuit of the highest known branch of science, they would compel an acknowledgment of abilities hitherto withheld from the service. Should it be creditably and usefully conducted, no one will more sincerely rejoice; if it fail, none will more poignantly regret.

The instruments being of the highest character, both as to magnitude and execution, the first question presented is, who are to use them? It would unquestionably be better to have permanent observers; but in so doing, the knowledge would be confined to a few officers, and not disseminated in the navy. On the other hand, frequent changes will assuredly destroy its efficiency as an observatory, by impairing the confidence of astronomers in its results, necessarily acquired but by long and laborious experience. I had the honor to present a report on this subject, June 15, 1842, and subsequent reflection induces me to believe that, with slight modifications, the organization there proposed would be the best *for the navy.* The personnel of a *National Observatory* would be governed by different motives and objects, and permanence should certainly be a sine qua non; but, regarding this only as a naval observatory, it is of the utmost importance that we give to the service the greatest possible benefit from it.

Two officers can be constantly and usefully employed at each of the larger instruments, viz: *transit, mural circle, transit in prime vertical,* and *equatorial;* and the *magnetical observatory* will require at least four. They should possess a knowledge of the higher mathematics, and a taste for astronomical pursuits. To such requisites they must add patience, perseverance, and endurance; for the refinements of astronomy entail long hours of delicate adjustments and calculations, as well as continued loss of sleep, and exposure to the external temperature at all seasons. Such officers it may be somewhat difficult to select immediately; but, with an eye to the future, inducements should be offered midshipmen to give greater attention to study. Mathematics, being the groundwork, upon which must be built all scientific knowledge, I recommend to serious consideration the propriety of offering to the five midshipmen who annually pass the best examination in its higher branches, the *honor* of serving four years at the observatory. If no others are ordered, I think the emulation will be such in a few years, that the junior officers will deservedly attain a high character among scientific men.

2. To render their services most effective, it is alsolutely essential that the *working* men reside upon the premises. The best period for astronomical observations is between midnight and daylight, and during the winter months, when the ground is at a lower temperature than the air; but important phenomena occur at all hours of the night. The magnetical observations in European observatories are made at the beginning of every hour throughout the day and night. There must therefore be one person constantly on duty; and, unless the Government provides quarters, the same observer will be obliged to remain all night, since it will be impossible for him to leave his post and awake a successor perhaps a mile distant. An occasional night thus passed might be attractive from its novelty, more especially during those extraordinary disturbances of the magnet which have been called "magnetic hurricanes;" but when it occurs every third or fourth night, the charm is soon broken, and the observation, becoming a matter of duty, is performed listlessly at best. Nor do I think one can faithfully watch whole nights without soon impairing his health. If the assistants live at a distance from the observatory, it cannot be expected that they will proceed to their labors with the same cheerfulness as if they resided within the enclosure. Every man deems it important to locate his domicil near his place of business, in order that he may lose the least time in passing to and fro; this, too, when his visits to it are only by daylight, over a frequented road; of how much greater importance must it then be to him whose avocations subject him to midnight hours and an almost unsettled part of the city. Independently of the time lost, active bodily exercise temporarily unfits one for accurate observations, by influencing the nerves, at least the experience of six years proves it in my own case.

3. A suitable corps of observers being obtained, to what objects can their attention be most advantageously directed?

Meteorology.—Less advance has been made in this than in almost any other science, from want of systematic co-operation. We have now naval stations at nine different points of our extended country, embracing about 800 miles of latitude and 700 of longitude, and ships floating in every quarter of the globe, each of which might contribute its quota of information, without adding a dollar to the expense of the navy, except for paper on which to record observations. Thus: compare carefully with the standards, before issuing to the ships, &c., the barometers and thermometers, each of which should be numbered, for future reference. Send a book containing blank forms, and loose copies of the same for quarterly returns, with every set of instruments, specifying the manner of making observations, and requiring the officers of the watch to record them at the times indicated. These might be simultaneous, or, what would probably be better, at about the hours of maximum and minimum pressure, 9 A. M. and P. M., and 3 A. M. and P. M. They should be returned quarterly, and collated with observations made here; those at the naval stations might be returned monthly.

Magnetism.—So little attention has been given to the observations for declination (variation) of the magnetic needle, on shipboard, that navigators are rarely agreed as to its amount at any one place, and their discordances have proved of serious injury to the investigation of the laws which govern it. These may arise from several causes. The magnetic axis of the azimuth compass needle may not be in the same vertical plane as the north and south points of the card, and there be thus a *constant error;* the local attraction of the ship may not be taken into account at all; or the same amount be applied for every position of the compass. These compasses should all be examined at the depôt, and their errors ascertained with the declinometer. The same care should be taken in numbering and transmitting their errors, blank forms for observations, and directions for each requisite of the observation, as with the meteorological instruments. A convenient position should be chosen on deck for observations, and this spot rigidly adhered to throughout the cruise. The local attraction upon the azimuth compass at this spot is then to be ascertained and entered in the observation book for every point of the compass, and an observation should be required each day. The original observation, with the time, altitude, latitude, longitude, and every thing relating to it, should be embraced on one form, and the *results* on a second, both of which should be returned to the observatory, and revised by the officers in the magnetical department. With these precautions, much valuable information would be collected by our cruising ships, tending to elucidate points now in great obscurity, if not of absolute darkness.

Astronomy.—This is a subject requiring large and permanent instruments, in order to obtain important data; although the intelligent and inquiring officer at sea is not entirely debarred means or opportunities to add his mite to the stock. Occultations of stars of the third magnitude may easily be observed with a good spy glass, and a well-adjusted sextant in skilful hands might determine the position of a comet altogether invisible to fixed observatories. Astronomers have considered it advisable to select a particular class of observations for themselves, depending upon the character of their instruments, the numerical force of their assistants, or the apparent wants of astronomical science, care being taken to choose a field not previously occupied by their co-laborers. This appears the best mode of extending knowledge, as by limiting each one's views greater correctness is insured. Since the time of Maskelyne, the Greenwich observatory has devoted itself more especially to observations of the sun, moon, and planets, for the purpose of perfecting the lunar and planetary theories, as a means of more accurately determining the longitude. The advantages of obtaining it from observed distances of the moon from other heavenly bodies was spoken of by several astronomers as early as the sixteenth century, but it was not until the telescope had been applied to the mural quadrant, and such advances made in physical astronomy from a large number of observations deserving confidence, that Mayer was enabled to detect the form of the inequalities in the lunar theory, and computed tables of sufficient accuracy to be used for this purpose. Mayer's labors were, at that day, considered of such vast importance to navigation, that the Board of Longitude handsomely rewarded his widow. Nearly two centuries have elapsed, and our satellite has been the subject of unceasing observation as well at other observatories as at Greenwich, and there are yet small disturbances to be accounted for, the observed and computed places being rarely in accordance.

The elder Herschell, having perfected gigantic reflectors, gave his attention to explorations in the remotest depths of space, and his persevering industry was rewarded beyond the success of any subsequent astronomer.* His catalogues of double stars and nebula are among the most valuable papers of the philosophical transactions. The distinguished astronomer at Konigsberg (Bessel) devoted a large portion of many succeeding years to the observations of zones of small stars, extending from 15° south to 30° north declination. Struve, first at Dorpat, and since at Pulkova, obtained from Frauenhofer the most magnificent specimen of achromatic telescopes ever produced, and, as the result of his labors with the former, has given us his celebrated "Catalogus Magnus." The very learned astronomer royal of England (G. B. Airy, Esq.) has persevered in the policy characteristic of the Greenwich observatory, from the time he became the astronomer at Cambridge; and the volumes of observations issued by him annually from that observatory, and since from Greenwich, are examples of excellence we may hope to imitate if we cannot equal. Sir John Herschell, pursuing the path traced out by his father, has rendered the name illustrious to all future time. Henderson, at Edinburgh, and Challis, at Cambridge, follow the same course of observations as at Greenwich. Johnson, Radcliffe astronomer at Oxford, is engaged in making a catalogue of the stars within 50° of the north pole. Lamont, at Munich, is reobserving Bessel's zones; and Rumcker, at Hamburg, is about completing a catalogue of stars observed by him at that observatory.

From what has been said of the moon, it is evident that the meridian instruments could not be more usefully employed than in determining her place at transit; but, for the same reason, I would include the sun and planets. The short period which has elapsed since the discovery of the four small planets, (less than half a century,) and their extreme minuteness, has prevented many observations, and their places are not well known.†

* I am not aware that the 7th satellite of Saturn, the 1st, 3d, and 5th, of the Georgian, or its two perpendicular rings, have ever been seen by another.

† On reference to the Greenwich observations for 1840, it will be seen that there were 126 observations of the Sun, 112 of the Moon, 24 of Mercury, 75 of Venus, 10 of Mars, 28 of Vesta, 8 of Pallas, 4 of Ceres, 56 of Jupiter, 47 of Saturn, and 45 of the Georgian. Juno was not observed. The extreme observed differences of right ascensions and declinations from the tabular places are—

Sun.		Moon.		Mercury.		Venus.		Mars.		Vesta.	
AR.	D.	AR.	D,	AR.	D.	AR.	D.	AR.	D.	AR.	D.
"	"	"	"	"	"	"	"	"	"	"	"
— 0.62	— 3.59	— 0.63	— 10 99	— 0.53	— 5 06	— 0.92	— 5.47	— 0.60	— 5.41	+ 4.41	— 2.17
+ 0.35	+ 2.92	+ 1.17	+ 13.06	+ 0.50	+ 7.75	+ 0.53	+ 4.60	+ 0.09	— 2.40	+ 2.12	+ 4.54

Pallas.		Ceres.		Jupiter.		Saturn.		The Georgian.	
AR.	D.	AR.	D.	AR.	D.	AR.	D.	AR.	D.
"	"	"	"	"	"	"	"	"	"
+ 8.57	— 20.54	+ 3 91	— 21.36	— 0.96	+ 3 07	— 1.00	+ 19.50	+ 5.94	— 25.93
+ 4.53	+ 2 30	+ 3.45	— 15.60	— 0.13	— 1.77	— 0.21	+ 10.22	+ 5.25	— 21.65

This remark will apply to a large portion of the stars whose declination exceeds 15° south; and I know no more important service the observatory can render astronomy than the accurate determination of the places of all the stars between 15° and 35° south declination, to the ninth magnitude, inclusive. Its geographical position, and the great serenity of our climate, renders the task facile, and the work might readily be accomplished in five years.

The apparent magnitude of every star should be carefully estimated and recorded at the time of its observation, as a means of detecting physical changes not otherwise to be perceived, unless, indeed, the gradations of brightness should be of the extraordinary character of the stars which appeared in 1572 and 1604, and were visible even by daylight to the unassisted eye. The periods of o Ceti, β Persei, χ Orionis, γ Cygni, 30 Hevelius, θ Cygni, and δ Cephei, are tolerably well known, and the Abbé Vico, at the observatory of the Roman College, has recently announced a short period for ζ Ursæ Major. About 40 others are suspected, but there are doubtless many periodical stars of which we are totally ignorant. It is not a little curious, that, in attempting to account for these changes, Thomas Dick, L. L. D., says, in 1828, "I am disposed to consider it as highly probable that *the interposition of the opaque bodies of large planets revolving around such stars* may, in some cases, account for the phenomena;" and in 1844, Bessel, "by a long and laborious examination of the places of Sirius and Procyon, as deduced from the observations of different astronomers since the year 1755, (the epoch of Bradley's observations,) including his own at the Konigsberg observatory, has come to the conclusion that the *proper motion of these two stars are not uniform*, but deviate from that law, the former in right ascension and the latter in declination, in a very sensible degree. Astronomers will at once perceive the importance of this conclusion, which proves that the stars describe orbits in space, under the influence of dynamical laws and central forces. Reasoning on the observed character of the deviations which he has established, M. Bessel comes to the singular and surprising conclusion, that *the apparent motions of these two stars are such as might be caused by their revolutions about attractive but non-luminous* central bodies, not very remote from them, respectively."

But little, if any, attention was given to the subject of *double and multiple stars*, until the time of Sir William Herschell, the whole number previously known not exceeding 20. Believing that the question of annual parallax might be solved by a careful measurement of the distances and angles of position of some of these bodies when the earth was in opposite points of its orbit, he perceived that many of them "are not stars that appear double from a fortuitous juxtaposition, but in reality are intimately connected, forming binary systems, in which either one star revolves round the other, or both round their common centre of gravity." From this period, an impulse was given to this branch of astronomy, and the list of double stars contributed to the Royal Society, whose angles of position and distance he had determined, amounted to 500. His son, Sir John Herschell, Sir James South, Struve, Dunlap, and Dawes, have subsequently increased the number to above 6,000; catalogues of which are published in the Philosophical Translations, the Memoirs Royal Astronomical Society, and a volume by Struve, entitled "Catalogus Novus." Among the multitude, the periodic times of many have been ascertained; of which α Geminor, γ Virginis, γ Leonis, ε and ξ Bootis, ζ Cancri, 61 Cygni, ξ Ursæ Major, δ and η Coronæ, and 70 Ophiuchi, are probably best known. Indeed, that of η Coronæ being but little more than half the periodic time of Saturn, it has almost completed a second entire revolution since discovery as a double star. The time which has elapsed since the completion of the "Catalogus Novus," affords reasonable supposition that a re-examination of the angles of position and distance could not fail to add a great number to our knowledge of binary systems. It is not alone on account of the time that preference is given to Struve's Catalogue, but that the Dorpat and Washington telescopes being the productions of the same master opticians, and of the same dimensions, the same objects examined with each, should give equally satisfactory results.

By the completion of large and highly finished telescopes, new impulse has been imparted to physical astronomy. Clusters and masses of light scattered over the heavens, of which earlier observers had no knowledge, exhibit, by means of these instruments, the most wonderful objects of creation. Upon directing the telescope to those that are visible to the eye, they are resolved into multitudes of minute stars, some few of which, perhaps, are enveloped in luminous matter, which the highest powers of the instrument fail to separate into constituent particles. The groups visible to the unassisted eye form but a small fraction of the number whose places have been determined, and for which, as in the case of the double stars, we are indebted to the example set by the elder Herschell. Messier's (the first) list, published in the "Connoissance des Temps" 1783–'84, contains 103. Of these, Herschell found 44 to be composed entirely of stars, 18 of small stars accompanied with nebulous matter, and 41 only, *nebulæ.* Aided by his sister, about 2,000 new objects were discovered, and descriptions of them communicated to the Royal Society at different times. Sir John Herschell is, perhaps, the most important contributor. A descriptive list of 2,500, with their right ascensions and declinations for 1830, was published in the Philosophical Translations for 1833; but their value to physical astronomy is in the exquisite delineations of the most remarkable nebulæ accompanying the list; such portraits being the great desiderata. Mr. Dunlap, at Paramatta, has also added to the number; and the valuable paper by Mr. E. P. Mason, giving the details of observations by himself and Mr. H. L. Smith, which was read before the American Philosophical Society, April, 1840, entitle them to the gratitude of future astronomers, for the elaborated drawings of the nebulæ observed. It being established that the laws of gravity extend to the utmost regions of space of which we have knowledge, it was early supposed that the irregular masses of nebulous matter must be constantly undergoing change of form and density; but the inquirer has been met at the outset of investigation, and the nebular hypothesis, from want of drawings to be relied on, is but little more advanced than at its promulgation half a century ago. Huygens, discoverer of the great nebulæ in Orion, has given its figure, and there are sketches to be found in the early numbers of the "*Berliner Jahrbuch,*" but, from the imperfection of instruments, the extreme difficulty of correctly portraying such objects, and the coarseness of the engravings at that day, no warrantable conclusion has been drawn. Speaking of the nebulæ of Orion, Sir John Herschell says: "Several astronomers, on comparing this nebulæ with the figures of it handed down to us by its discoverer, Huygens, have concluded that its form has undergone a perceptible change; but when it is considered how difficult it is to represent such an object duly, and how entirely its appearance will differ even in the same telescope, according to the clearness of the air or other temporary causes, we should readily admit that we have no evidence of change that can be relied on."

The amount of labor required of the observer in making a faithful representation of a nebulæ may be entirely lost when his copy comes under the engraver's tool; and but a small number must necessarily be the reward of his devotion. This, with the great expense attendant on their proper execution, has doubtless been a serious drawback. The difficulty has been obviated, however; and science of our own day, rendering nature subservient to art, leaves nothing for the judgment of the astronomer or the tool of the graver by which to misrepresent the works of the Creator. "Fortunately, the Roman astronomers have hit on means effectually to prevent future mistakes of vision or delineation. They have brought the Daguerreotype to bear on the object, and, throwing the photographic image of the nebulæ and its stars on a lithographic stone, have, by an ingenious invention of the Signor Rondoni, which is still kept secret, fixed it there. From that stone they have been able to take impressions on paper, unlimited in number, of singular beauty, and of perfect precision, each star, each filmy nebulous streak, faithfully depicting its own position. The scale is large, proportionate to the magnifying and light-collecting powers of the specula employed; the effect is wonderful, and is heightened by being thrown on a beautiful deep azure ground."* Copies of some of these remarkable engravings have been presented to the observatory by Professor Curley, of Georgetown College; and they are as stated by the correspondent of Silliman, except that there is a want of sharpness in some of the stars, which I have not perceived in the nebulæ. This may arise from a slight tremor in the telescope, or other causes experience will probably correct when Rondoni's process comes to be made known, as he has promised. I need not recommend that the apparatus be obtained so soon as it is divulged; the facilities it offers of delineating the surface of the moon, and tracing from day to day the motion of the spots over the Sun's disc, must be sufficiently obvious.

These are the only observations to be made *seriatim* with the equatorial, unless, indeed, the rotation of the planets be made a subject of investigation; and to the determination of the revolution of the only large planet whose time is unknown, (the Georgian,) it is scarcely adequate. Jupiter, Mars, and Saturn, have been well ascertained for many years; Venus has been the object of observation at the Roman College for three years, and Mercury is the only one that offers a field for creditable labor. Eclipses, occultations, and the transit of Mercury over the sun's disc in May next, will, of course, form a part of the duty of the observers, and I hope that unremitting employment may be given to this instrument. In a letter lately received from the Astronomer Royal (Lamont) at Munich, he says: "I am glad to see the rapid progress astronomy is making in America; at this rate, you will soon have more great telescopes than Europe, and a better opportunity of using them. It is remarkable, that in Europe only those observatories have been furnished with great telescopes where the climate is most unfavorable. The only exception, perhaps, is Kasan, where, however, nothing has as yet been done." At Munich, the humidity of the cli-

* Silliman's Journal, vol. XLIV, 1843.

mate is such, that the object glass of the equatorial is kept in the library all winter; Dr. Lamont informing me that occasions to use it were so very rare, the injuries to which it would be exposed from dampness in the observatory were not compensated, and he deemed it advisable to keep it in a warm and uniform temperature. There was not a clear night during my stay in Munich, (ten days,) in January, 1843, nor do I remember one that I could consider perfectly clear in London all February of the same year. These facts will, it is hoped, cause due appreciation of this superb instrument.

Römer, whose name is rendered illustrious by his discovery of the progressive motion of light, shortly after his invention of the transit instrument, erected one in the prime vertical of the Copenhagen observatory, for the purpose of determining the equinoxes by observations of the sun near the equator. Improvements in instruments caused this method to be superseded, and the transit was not much used in this position till, in 1824, Bessel pointed out (*Schumacher's Astronomische Nachrichten*, No. 40) its great importance in obtaining the latitude, when the declinations of the observed stars are known; the differences of latitude when the same stars are observed at two stations, and the declinations are unknown; and, conversely, the declinations of the stars when the latitude is known. In geodesic operations by himself in Prussia, Struve in Russia, more recently in the United States by Professor Bache and Major Graham and others, it has been extensively adopted, with unqualified satisfaction; but it was left for the distinguished founder of the Pulkova observatory to designate a new task for it, and apply it in the ulterior researches of *aberration, nutation,* and *annual parallax.*

From the publication of the Copernican theory, (1543,) astronomers felt the want of a concluding link in the chain of evidence, and earnestly endeavored to supply it. Among those who should have been its earliest defenders, we find Tycho Brahé absolutely rejected it, though no one had like opportunities to follow the motions of the celestial bodies; and it was not until after the appearance of the new star in *Ophiuchi* (*Serpentis*) in 1604, that Galileo became openly its advocate. Galileo pointed out a mode by which the parallax might be determined, but did not realize it. Hook, in 1665, proposed to the Royal Society the erection of a zenith tube. Flamstead, and his pupil Horrebow, with the mural quadrant at Greenwich, and Cassini at Paris, each essayed to solve the problem, with apparent though very variable success. Finally, in pursuit of the same subject between the years 1725 and 1736, Bradley discovered the *aberration of light*, and, subsequently, the *nutation* of the earth's axis, the angle subtended by the orbit of the earth at the fixed stars being too minute for detection with his zenith sector. Defeat seems but to have increased the desire of triumph with later astronomers, and we find Brinkley and Pond, and Airy and Henderson, and a host of others, amounting to a greater array of talent laboriously employed than has ever been before enlisted in any one subject. Bringing to the contest the most exquisite production of the optician, with the profound refinements of mathematical science, Bessel at Königsberg, may exclaim, with the Syracusan philosopher, Eureka!

On the 23d October, 1838, he wrote to Sir John Herschell: "Having succeeded in obtaining a long-looked-for result, and presuming that it will interest so great and zealous an explorer of the heavens as yourself, I take the liberty of making a communication to you thereupon." "After so many unsuccessful attempts to determine the parallax of a fixed star, I thought it worth while to try what might be accomplished by means of the accuracy which my great Frauenhofer heliometer gives to the observations. I undertook to make this investigation upon the star 61 *Cygni*, which, by reason of its great proper motion, is perhaps the best of all; which affords the advantage of being a double star, and on that account may be observed with great accuracy; and which is so near the pole that, with the exception of a small part of the year, it can always be observed at night at a sufficient distance from the horizon." Bessel began his observations in September, 1834, but, being dissatisfied, they were soon discontinued, and not systematically resumed till 1837. He goes on to say: "I selected, among the small stars which surround that double star, two between the 9th and 10th magnitudes, of which one (a) is nearly perpendicular to the line of direction of the double star; the other (b) nearly in this direction. I have measured with the heliometer the distances of these stars from the point which bisects the distance between the two stars of 61 *Cygni;* as I considered this kind of observation the most correct that could be obtained, I have commonly repeated the observations sixteen times every night. When the atmosphere has been unusually steady, I have, however, made more numerous repetitions; although by this I fear the result has not attained that precision which it would have possessed by fewer observations on more favorable nights. This unsteadiness of the atmosphere is the great obstacle which attaches to all the more delicate astronomical observations. In an unfavorable climate we cannot avoid its prejudicial influence, unless by observing only on the finest nights; by which, however, it would become still more difficult to collect the number of observations necessary for an investigation." The positions and distances of the stars for the beginning of 1838, and the observations up to October 2d, are detailed, from which he deduces as "the most probable value of the annual parallax of 61 Cygni $= 0''.3136$," and concludes his communication as follows:

"As the mean error of the annual parallax of 61 *Cygni* ($= 0''.3136$) is only $\pm$ ''0.0202, and consequently not $\frac{1}{15}$ of its value computed; and as these comparisons show that the progress of the influence of the parallax, which the observations indicate, follows the theory as nearly as can be expected, considering its smallness, we can no longer doubt that this parallax is sensible. Assuming it $0''.3136$ we find the distance of the star 61 *Cygni* from the sun 657,700 mean distances of the earth from the sun; light employs 10.3 years to traverse this distance. As the annual proper motion of α *Cygni* amounts to $5''.123$ of a great circle, the *relative* motion of this star and the sun must be considerably more than sixteen semi-diameters of the earth's orbit, and the star must have a constant aberration of more than $52''$. When we shall have succeeded in determining the elements of the motion of both the stars forming the double star, round their common centre of gravity, we shall be able also to determine the sum of their masses. I have attentively considered the preceding observations of the relative positions; but I consider them as yet very inadequate to afford the elements of the orbit. I consider them sufficient only to show that the annual angular motion is somewhere about $\frac{2}{3}$ of a degree; and that the distance at the beginning of this century had a minimum of about $15''$. We are enabled hence to conclude that the time of a revolution is more than 540 years, and that the semi-major axis of the orbit is seen under an angle of more than $15''$. If, however, we proceed from these numbers, which are merely *limits*, we find the sum of the masses of both stars less than half the sun's mass. But this point, which is deserving of attention, cannot be established until the observations shall be sufficient to determine the elements accurately."*

There can be no question, that the cause of delay was the imperfection of the instruments employed and modes of observation adopted. The Astronomer Royal at Greenwich, in a report on the parallax of α *Lyræ* to the Astronomical Society,† only a year previously, having informed the society, that "the annual parallax of α Lyræ, though undoubtedly existing, is too small to be made sensible to our most accurate instruments," (mural circles.) In a subsequent volume of the Greenwich observations, it is stated that the zenith sector has not fulfilled expectations formed of it; and I have already quoted Struve's prediction, that the transit in the prime vertical must eventually supersede it in the ultimate researches of aberration, nutation, and the annual parallax.‡

It is not probable that the constant of aberration will be much changed by succeeding observers. Since Bradley's time, Zach and Bessel have made use of his observations for its determination; Brinkley, Laplace, and Woodhouse, have also computed its value; but among the most recent and satisfactory are those of Baron Lindenau, Richardson, and Struve—their quantities being respectively 20''.4486, 20''.5030, and 20''.4711. This last was determined from observations with the transit erected in the prime vertical, at Pulkova, and differs from the mean of the other two only in the third decimal. As it is the mean of six results by stars of different magnitudes, and approximates so closely to the value of Mr. Richardson, as ascertained from 5,000 observations at Greenwich, this question may be considered as almost absolutely decided.

The co-efficient of *nutation*, requiring a longer period of observation for its determination, is not so accurately known; observations variously giving it from 8''.60 to 9''.65. La Place *theoretically* finds the lunar 9''.40, whilst Dr. Brinkley's observations make it 9''.25; the solar 0''.493, and Brinkley's observations 0''.545. It is greatly desired that these differences be accounted for, and observations of special stars continued through a revolution of the lunar nodes, for the purpose of definitely fixing it.

The *annual parallax* demands further investigation. "It seems highly desirable that observations of 61 *Cygni* and α *Lyræ* should be made with another instrument. The confirmation of the results previously obtained would set at rest any remaining doubts, (if any still remain;) at the same time that the repetition of the measures is, in the present stage of the inquiry, the only practical and legitimate way of expressing them."§ These two stars pass but a few minutes south of the zenith of Washington, and are therefore most favorably situated for observation with the prime vertical transit; for although Bessel has verified his first measurements with the heliometer, and obtained almost the same results for the parallax of 61 *Cygni*,‖ it will be a triumph of science, if two differently constructed instruments accord precisely in such minute amounts. The difference of declination of the sun and this star, when they have the same right ascension,

* Monthly Notices Royal Astronomical Society, vol. iv.
† Memoirs Royal Astronomical Society, vol. x.
‡ Bulletin de l'Academié des Sciences de St. Petersburg, tom. x.
§ Mr. Main on the present state of our knowledge of parallax of the fixed stars. Memoirs Royal Astronomical Society, vol. xii.
‖ Monthly Notices Royal Astronomical Society, vol. v.

being about 55°, it is probable that it may be observed at transit over the prime vertical throughout the year; α *Lyræ* certainly can. *Castor* and *Arcturus* may also be satisfactorily observed to this end. That the instrument will be competent to determine such small amounts, Struve says: "With such an instrument, and methods of observation and precaution acquired by a careful study of its construction and exterior conditions, there is no doubt that the astronomer will be able to determine changes in the declinations of zenithal stars to the most minute fractions of a second."* That his conclusions are well founded is necessarily inferred, when we know that they are based on the experience of nearly two years' use of the instrument, and his merits as a philosopher are too well established to suppose that he would risk an opinion hastily. If further evidence be required, the observations published by him witness an uniformity hitherto unknown in astronomical annals.

4. It is too frequently the case, that the obligation is considered to terminate with the record of the observation, and interest in it ceases, whilst the labors of the astronomer can only begin at this point.† To be useful, observations must be reduced and published, the originals, with all applied corrections, being given in detail, and accompanied by notes (made at the instant) explanatory of every fact that can influence final results. The published Greenwich observations are an example of care and fidelity which may serve as a pattern to all other observatories. Care should be taken at the outset to prevent the accumulation of unreduced data, and every month's computations made to keep pace with the observations. If this be not the case, the time must shortly come when a part of them will be set aside, or additional force engaged, to bring up arrearages; either of which is objectionable. It is preferable, therefore, that, making allowance for unfavorable weather, no greater number of observations be made during any night, than can be calculated on the succeeding day. By this means, the observatory may complete its volume within a month after the termination of the year, and the value greatly enhanced by an early dissemination of the fruits of its labor.

In conclusion, I quote the language of one of Nature's master minds,‡ who, invading her arcanum, tore away the veil, and, exposing the system to benighted worshippers, leaves an imperishable monument in the details of its *mechanism:*

"Vue dans son ensemble, l'astronomie est le plus beau monument de l'esprit humain, le titre le plus noble de son intelligence. Seduit par les illusions des sens et de l'amour-propre, il s'est regardé pendent long-tems comme le centre du mouvement des astres; est son orgeuil a été puni par les vaines frayeurs qu' ils lui ont inspirées. Enfin, plusiers siècles de travaux ont fait tomber le voile qui couvrait le systême du monde. L'homme alors, s'est vū sur une petite planète, presque imperceptible dans la vaste étendue du systême solaire, qui lui même, n'est q'un point insensible dans l'immensité de l'espace. Les resultats sublime auxquelles cette découverte l'a conduit, sont bien propres à le consoler du peu de place qu'elle lui assigne dans l'univers. Conservons précieusement, augmentons même, le depôt de ces hautes connoissances, les délices des êtres pensans. Elles

---

* Bulletin de l'Academiê des Sciences de St. Pètersburg, tom. x.

† On the Progress of Astronomy, by G. B. Airy, Esq., Reports British Association, 1832.

‡ Laplace, Systême du Monde, liv. V, chap. 6.

ont rendu d'importans services, à la navigation et á la géographie; mais leur plus grand bien-fait, est d'avoir dissipé les craintes occasionées par les phénomènes célestes extraordinaires, et detruit les erreurs nées de l'ignorance de nos vrais rapports avec la nature, erreurs d'autant plus funestes, que l'ordre social doit reposer uniquement sur ces rapports. VERITÉ, JUSTICE; voilà ses lois immuables. Loin de nous, la dangereuse maxime, qu'il est quelque-fois utile de s'en écarter, et de tromper ou d'asservir les hommes, pour assurer leur bonheur. De cruelles expériences ont prouvé dans tous les tems, que ces lois sacrées ne sont jamais impunément enfreintes."

Respectfully submitted.

J. MELVILLE GILLISS,
Lieutenant U. S. Navy.

Hon. JOHN Y. MASON,
Secretary of the Navy, Washington.